

## VERIFICATION OF TRANSLATION

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do hereby declare that I have a thorough knowledge of the Japanese and English languages and that  
the writing contained in the following pages is a correct translation of the attached Japanese Patent  
Office Certificate bearing the file reference

Japanese Patent Application No. 2004-059106

Declared at Tokyo, Japan

This 13th of May, 2010

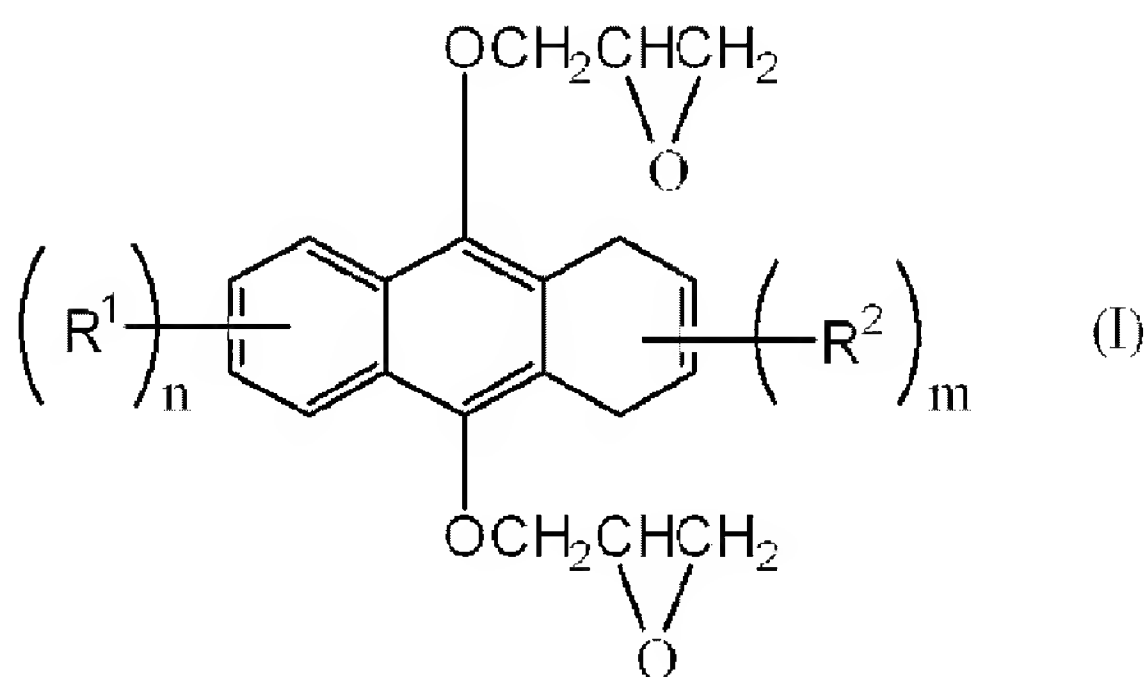
Keiko Hoshino

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## CLAIMS

1. A sealant epoxy-resin molding material, comprising an epoxy resin (A) and a hardening agent (B), wherein the epoxy resin (A) contains a compound represented by the following General Formula (I):

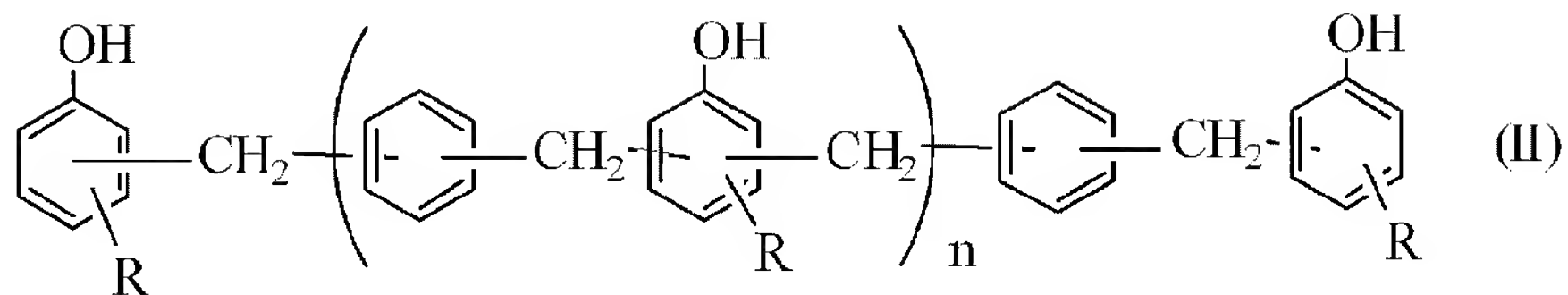
[Formula 1]



(in General Formula (I),  $R^1$  represents a group selected from substituted or unsubstituted hydrocarbon groups having 1 to 12 carbon atoms and substituted or unsubstituted alkoxy groups having 1 to 12 carbon atoms, and the groups  $R^1$  may be the same as or different from each other;  $n$  is an integer of 0 to 4;  $R^2$  represents a groups selected from substituted or unsubstituted hydrocarbon groups having 1 to 12 carbon atoms and substituted or unsubstituted alkoxy groups having 1 to 12 carbon atoms and the groups  $R^2$  may be the same as or different from each other; and  $m$  is an integer of 0 to 2).

2. The sealant epoxy-resin molding material according to Claim 1, wherein the hardening agent (B) contains a compound represented by the following General Formula (II):

[Formula 2]



(wherein, R represents a group selected from a hydrogen atom  
 5 and substituted or unsubstituted monovalent hydrocarbon groups  
 having 1 to 10 carbon atoms; and n is an integer of 0 to 10).

3. The sealant epoxy-resin molding material according to  
 Claim 1 or 2, further comprising a hardening accelerator (C).

10

4. The sealant epoxy-resin molding material according to  
 Claim 3, wherein the hardening accelerator (C) is  
 triphenylphosphine.

15

5. The sealant epoxy-resin molding material according to  
 Claim 3, wherein the hardening accelerator (C) is an adduct of  
 a tertiary phosphine compound and a quinone compound.

6. The sealant epoxy-resin molding material according to  
 20 any one of Claims 1 to 5, further comprising an inorganic filler  
 (D).

7. The sealant epoxy-resin molding material according to  
 Claim 6, wherein the content of the inorganic filler (D) is 60  
 25 to 95 wt % with respect to the sealant epoxy-resin molding material.

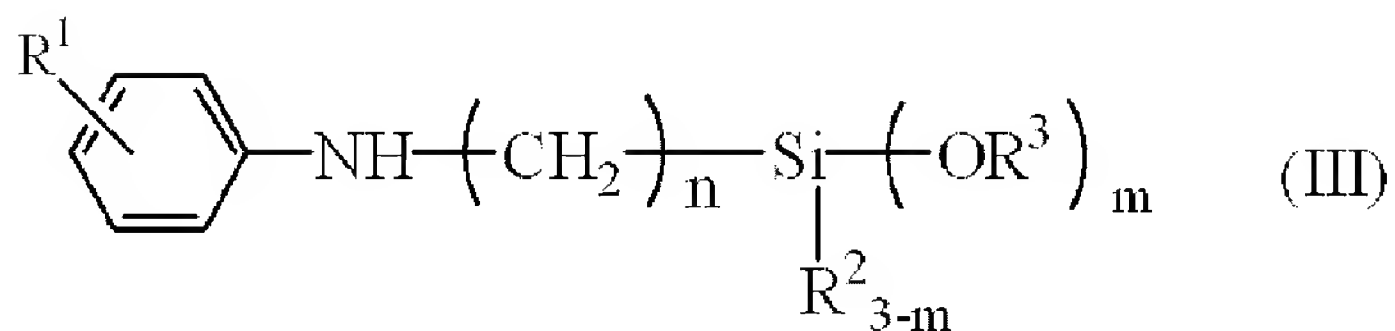
8. The sealant epoxy-resin molding material according to Claim 6 or 7, wherein the content of the inorganic filler (D) is 70 to 90 wt % with respect to the sealant epoxy-resin molding material.

9. The sealant epoxy-resin molding material according to any one of Claims 1 to 8, further comprising a coupling agent (E).

10. The sealant epoxy-resin molding material according to Claim 9, wherein the coupling agent (E) contains a secondary amino group-containing silane-coupling agent.

11. The sealant epoxy-resin molding material according to Claim 10, wherein the secondary amino group-containing silane-coupling agent contains a compound represented by the following General Formula (III):

[Formula 3]



(wherein, R<sup>1</sup> represents a group selected from a hydrogen atom, alkyl groups having 1 to 6 carbon atoms, and alkoxy group having 1 to 2 carbon atoms; R<sup>2</sup> represents a group selected from alkyl groups having 1 to 6 carbon atoms and a phenyl group; R<sup>3</sup> represents a methyl or ethyl group; n is an integer of 1 to 6;

and m is an integer of 1 to 3).

12. The sealant epoxy-resin molding material according to  
any one of Claims 1 to 11, wherein the epoxy resin (A) and the  
5 hardening agent (B) are melt-mixed previously.

13. An electronic component device, comprising an element  
sealed with the sealant epoxy-resin molding material according  
to any one of Claims 1 to 12.

## DESCRIPTION

[TITLE OF THE INVENTION] SEALANT EPOXY-RESIN MOLDING  
MATERIAL, AND ELECTRONIC COMPONENT DEVICE

[TECHNICAL FIELD]

5 [0001]

The present invention relates to a sealant epoxy-resin molding material and an electronic component device sealed with the molding material.

10 [BACKGROUND ART]

[0002]

Resin sealing has been mainly used in the field of element sealing of electronic component devices such as transistor and IC from the points of productivity, cost, and other, and epoxy  
15 resin molding materials have been used widely. It is because epoxy resins are well balanced in electrical properties, moisture resistance, heat resistance, mechanical properties, adhesiveness to insert materials, and others. These sealant epoxy-resin molding materials are flame proofed mainly with a combination of  
20 antimony oxide and a brominated resin such as tetrabromobisphenol A diglycidyl ether.

In the recent move for regulation of halogenated resins including decabrom and antimony compounds for environmental protection after concern about the dioxins problem, there exist  
25 an increasing need for non-halogenated (non-brominated) and non-antimony sealant epoxy-resin molding materials. In addition, bromine compounds are known to show an adverse effect on the

high-temperature storage stability of plastic-sealed IC's. It is desirable to reduce the amount of brominated resin also from the viewpoint.

There are many proposed flame-proofing methods without use  
5 of a brominated resin and an antimony oxide, including the methods of using a flame retardant containing no halogen or antimony, for example, red phosphorus (see, e.g., Patent Document 1), a phosphoric ester compound (see e.g., Patent Document 2), a phosphazene compound (see, e.g., Patent Document 3), a metal  
10 hydroxide (see e.g., Patent Document 4), a metal hydroxide and a metal oxide in combination (see, e.g., Patent Document 5), a cyclopentadienyl compound such as ferrocene (see, e.g., Patent Document 6), or an organic metal compound such as copper acetylacetonate (see, e.g., Nonpatent Document 1); methods of  
15 increasing the content of filler (see, e.g., Patent Document 7); and recently, methods of using a high flame-retardancy resin (see, e.g., Patent Document 8); and the like.

[0003]

[Patent Document 1] Japanese Patent Application Laid-Open  
20 No. 9-227765

[Patent Document 2] Japanese Patent Application Laid-Open  
No. 9-235449

[Patent Document 3] Japanese Patent Application Laid-Open  
No. 8-225714

25 [Patent Document 4] Japanese Patent Application Laid-Open  
No. 9-241483

[Patent Document 5] Japanese Patent Application Laid-Open

No. 9-100337

[Patent Document 6] Japanese Patent Application Laid-Open  
No. 11-269349

[Nonpatent Document 1] Hiroshi Kato, Function Materials  
5 Monthly, 11(6), 34 (1991).

[Patent Document 7] Japanese Patent Application Laid-Open  
No. 7-82343

[Patent Document 8] Japanese Patent Application Laid-Open  
No. 11-140277

10

[SUMMARY OF THE INVENTION]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

[0004]

However, there is a problem of deterioration in moisture  
15 resistance when red phosphorus is used as the sealant epoxy-resin  
molding material, problems of deterioration in moldability by  
plasticization and in moisture resistance when a phosphoric ester  
or phosphazene compound is used, problems of deterioration in  
flowability and mold release characteristics when a metal hydroxide  
20 is used, or a problem of deterioration in flowability when a metal  
oxide is used or when the filler content is raised. In addition,  
there is a problem of inhibition of curing reaction and thus,  
deterioration in moldability when an organic metal compound such  
as copper acetylacetonate is used. Further, in the method of using  
25 a high flame-retardancy resin, the electronic component devices  
obtained could not satisfy the requirement in flame resistance  
specified by UL-94 V-0 sufficiently.



As described above, any of the non-halogen, non-antimony flame retardant, the methods of raising the content of filler and of using a high flame-retardancy resin was not possible to obtain moldability, reliability and flame resistance the same as those  
5 of the sealant epoxy-resin molding materials using a brominated resin and antimony oxide in combination.

An object of the present invention, which was made under the circumstances above, is to provide a nonhalogenated and non-antimony sealant epoxy-resin molding material superior in  
10 flame resistance and still retaining reliability, for example, of moldability, reflow resistance, moisture resistance and high-temperature storage, and an electronic component device containing elements sealed with the same.

15 [MEANS TO SOLVE THE PROBLEMS]

[0005]

After intensive studies to solve the problems above, the present inventors have found that it was possible to achieve the object by using a sealant epoxy-resin molding material containing  
20 a particular epoxy resin, and completed the present invention.

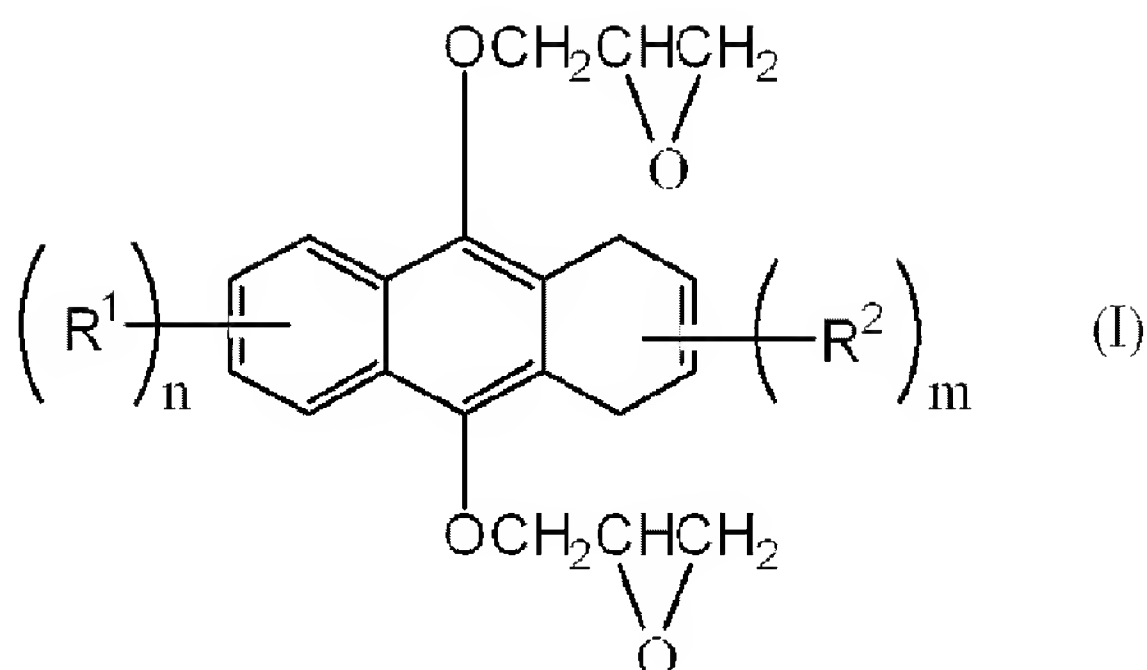
[0006]

The present invention relates to the following inventions.

(1) A sealant epoxy-resin molding material, comprising an epoxy resin (A) and a hardening agent (B), wherein the epoxy resin  
25 (A) contains a compound represented by the following General Formula (I):

[0007]

[Formula 1]

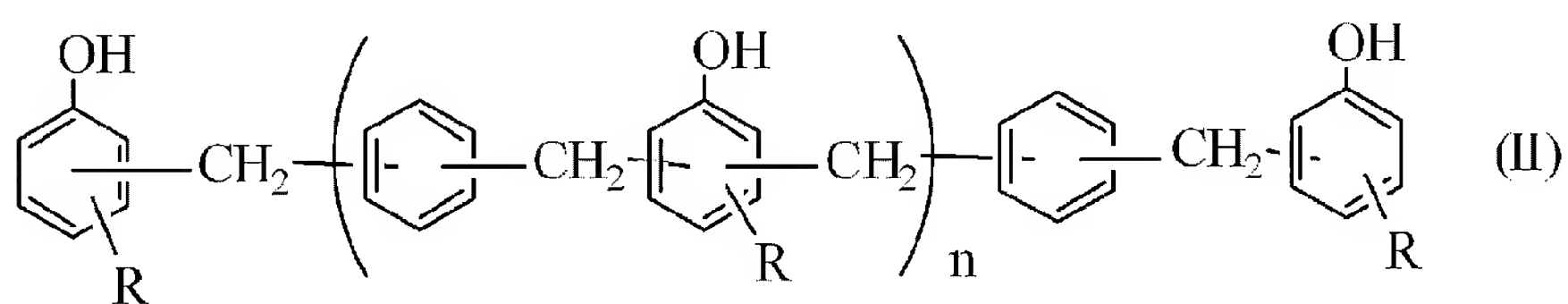


(in General Formula (I),  $\text{R}^1$  represents a group selected from substituted or unsubstituted hydrocarbon groups having 1 to 12 carbon atoms and substituted or unsubstituted alkoxy groups having 1 to 12 carbon atoms; and the groups  $\text{R}^1$  may be the same as or different from each other;  $n$  is an integer of 0 to 4;  $\text{R}^2$  represents a group selected from substituted or unsubstituted hydrocarbon groups having 1 to 12 carbon atoms and substituted or unsubstituted alkoxy groups having 1 to 12 carbon atoms and the groups  $\text{R}^2$  may be the same as or different from each other; and  $m$  is an integer of 0 to 6).

(2) The sealant epoxy-resin molding material described in (1), wherein the hardening agent (B) contains a compound represented by the following General Formula (II):

[0008]

[Formula 2]



(wherein,  $\text{R}$  represents a group selected from a hydrogen atom

and substituted or unsubstituted monovalent hydrocarbon groups having 1 to 10 carbon atoms, and n is an integer of 0 to 10).

(3) The sealant epoxy-resin molding material described in (1) or (2), further comprising a hardening accelerator (C).

5 (4) The sealant epoxy-resin molding material described in (3), wherein the hardening accelerator (C) is triphenylphosphine.

(5) The sealant epoxy-resin molding material described in (3), wherein the hardening accelerator (C) is an adduct of a tertiary phosphine compound and a quinone compound.

10 (6) The sealant epoxy-resin molding material described in any one of (1) to (5), further comprising an inorganic filler (D).

(7) The sealant epoxy-resin molding material described in (6), wherein the content of the inorganic filler (D) is 60 to 95 wt % with respect to the sealant epoxy-resin molding material.

15 (8) The sealant epoxy-resin molding material described in (6) or (7), wherein the content of the inorganic filler (D) is 70 to 90 wt % with respect to the sealant epoxy-resin molding material.

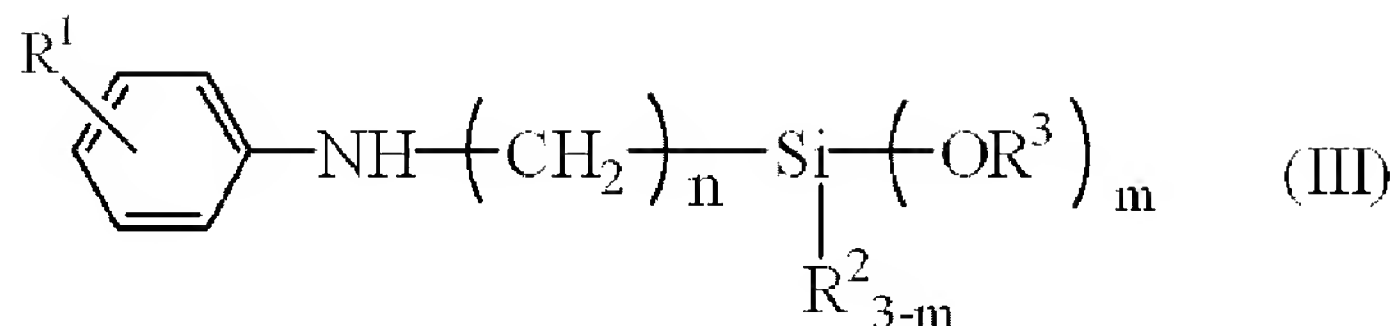
(9) The sealant epoxy-resin molding material described in  
20 any one of (1) to (8), further comprising a coupling agent (E).

(10) The sealant epoxy-resin molding material described in (9), wherein the coupling agent (E) contains a secondary amino group-containing silane-coupling agent.

(11) The sealant epoxy-resin molding material described in  
25 (10), wherein the secondary amino group-containing silane-coupling agent contains a compound represented by the following General Formula (III):

[0009]

[Formula 3]



(wherein,  $\text{R}^1$  represents a group selected from a hydrogen atom, alkyl groups having 1 to 6 carbon atoms, and alkoxy group having 1 to 2 carbon atoms;  $\text{R}^2$  represents a group selected from alkyl groups having 1 to 6 carbon atoms and a phenyl group;  $\text{R}^3$  represents a methyl or ethyl group;  $n$  is an integer of 1 to 6; and  $m$  is an integer of 1 to 3).

(12) The sealant epoxy-resin molding material described in any one of (1) to (11), wherein the epoxy resin (A) and the hardening agent (B) are melt-mixed previously.

(13) An electronic component device, comprising an element sealed with the sealant epoxy-resin molding material described in any one of (1) to (12).

[EFFECT OF THE INVENTION]

[0010]

The sealant epoxy-resin molding material according to the present invention gives electronic component devices and other products superior in flame resistance and is of significant value industrially.

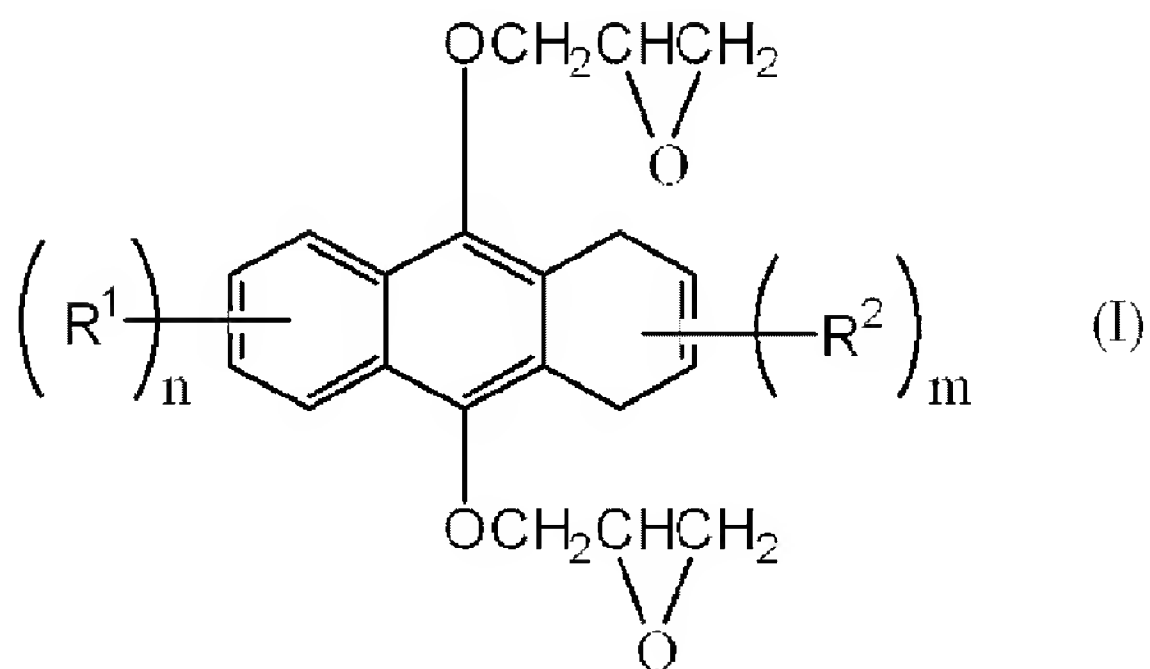
[BEST MODE OF CARRYING OUT THE INVENTION]

[0011]

The epoxy resin (A) according to the present invention is characterized by containing a compound represented by the following General Formula (I).

[0012]

5 [Formula 4]

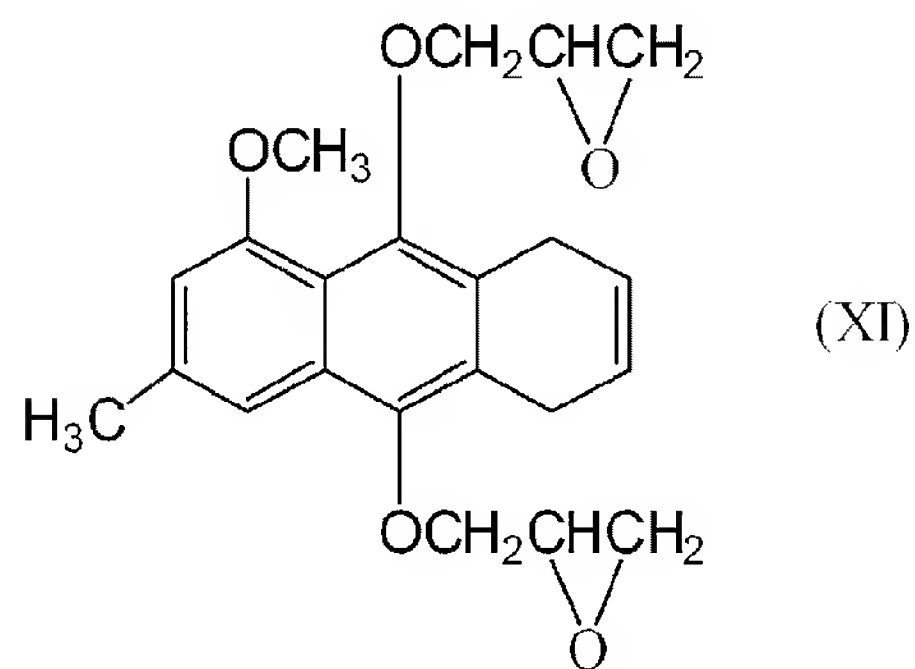
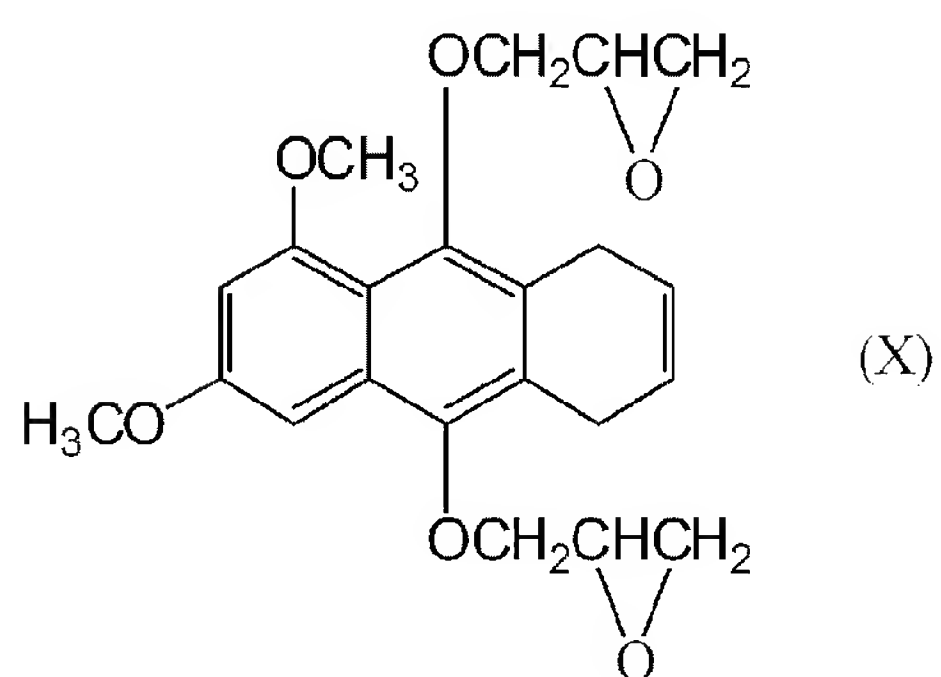
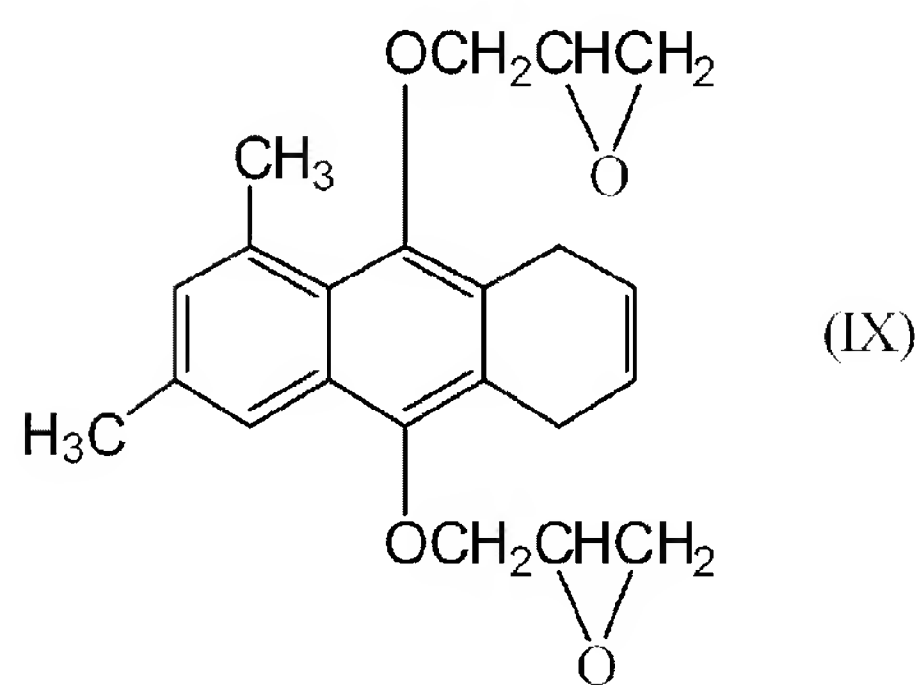
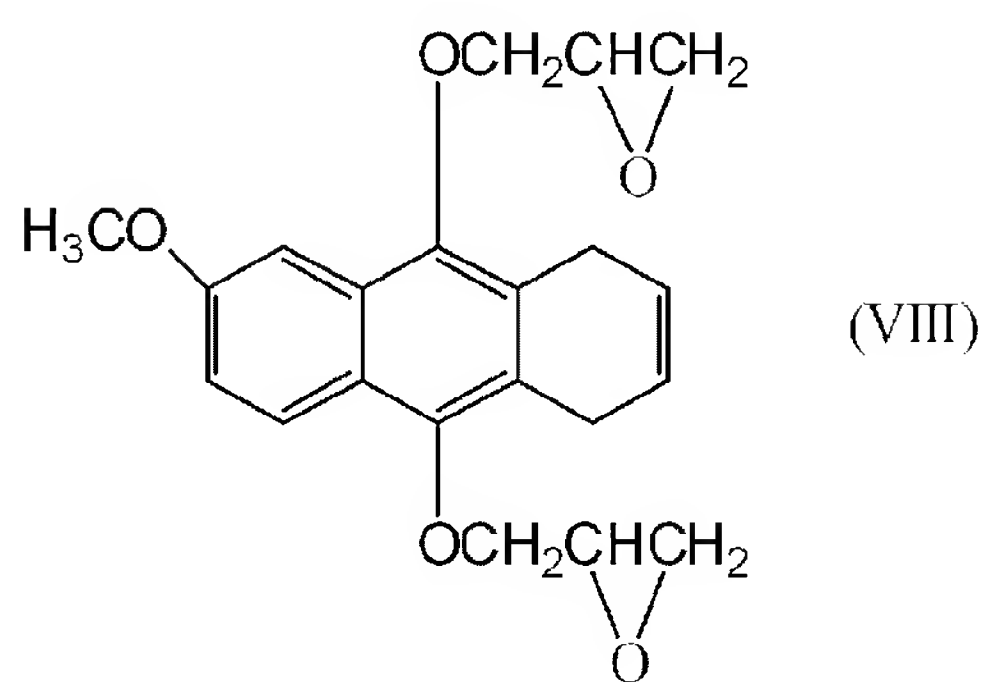
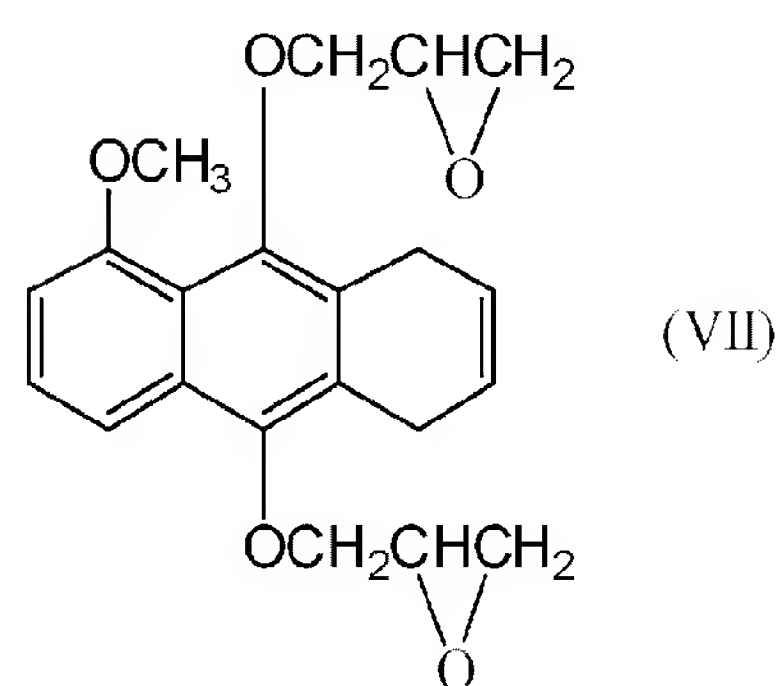
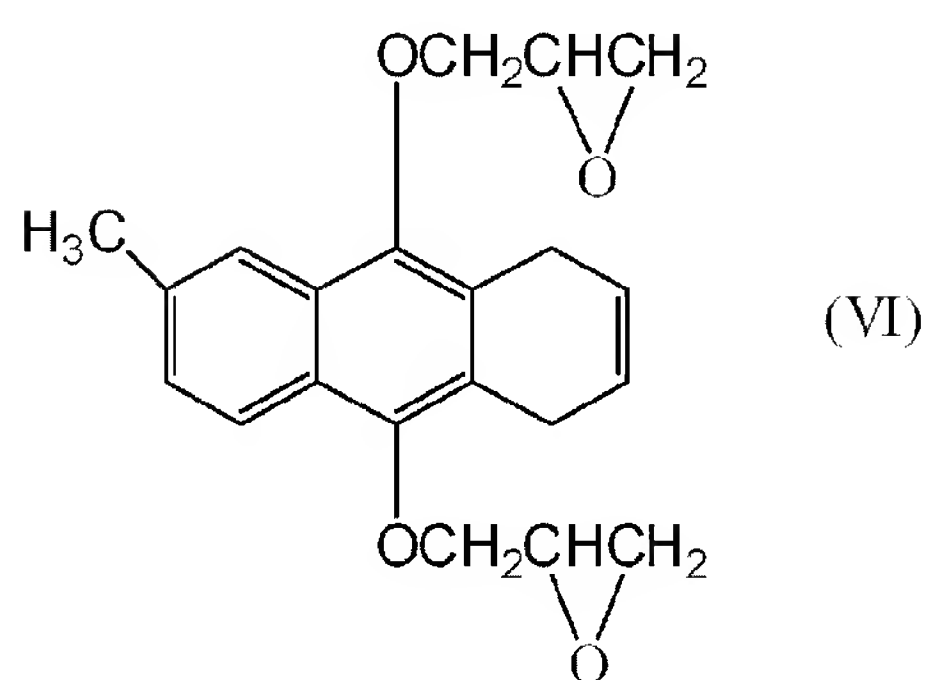
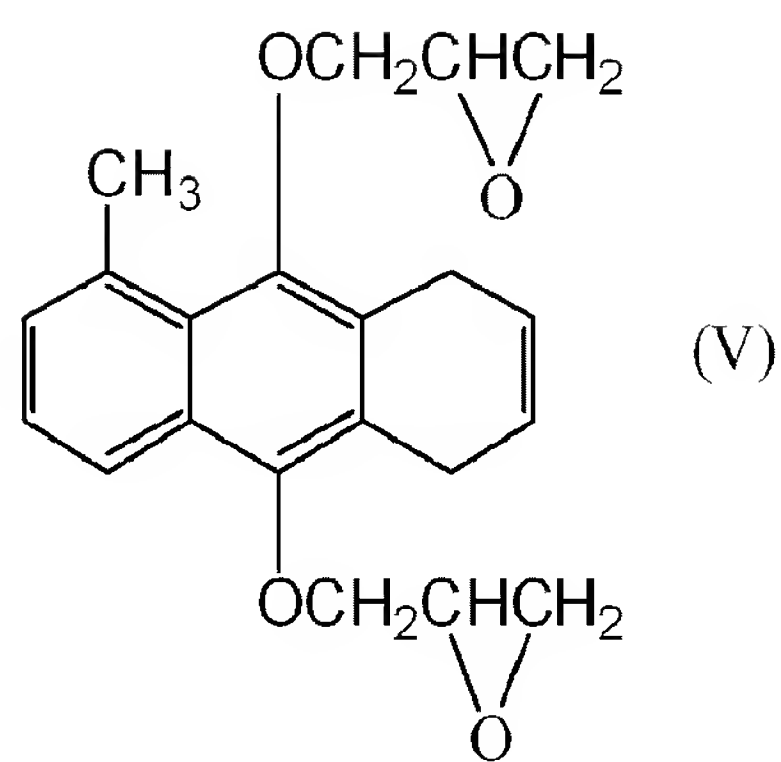
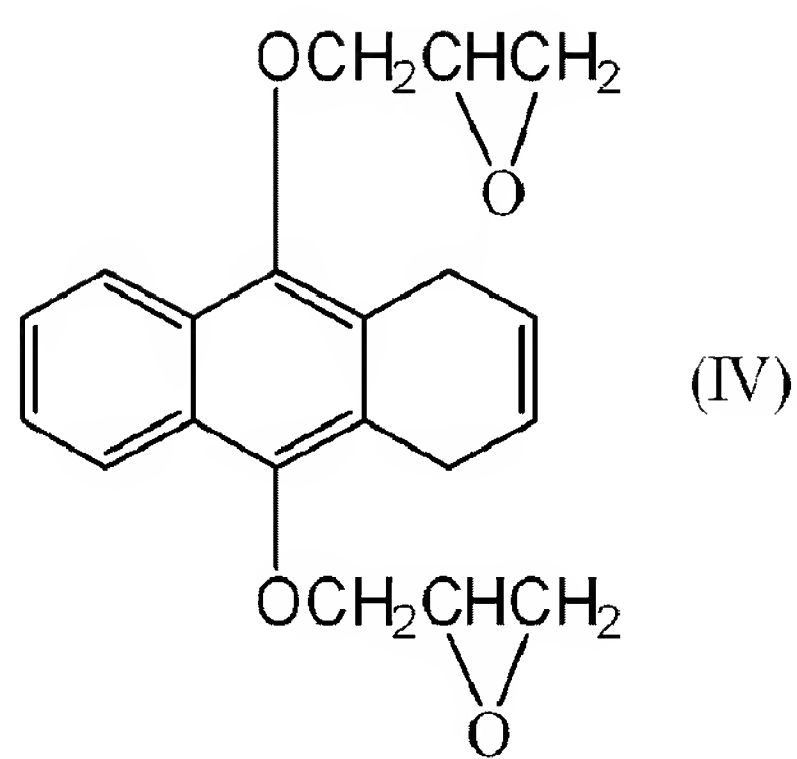


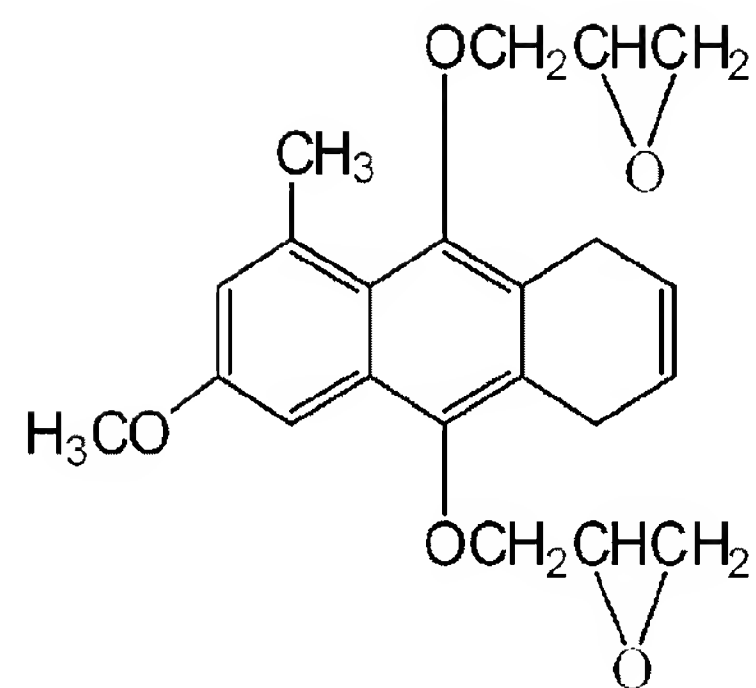
(in General Formula (I),  $\text{R}^1$  represents a group selected from substituted or unsubstituted hydrocarbon groups having 1 to 12 carbon atoms and substituted or unsubstituted alkoxy groups having 1 to 12 carbon atoms and the groups  $\text{R}^1$  may be the same or different from each other;  $n$  is an integer of 0 to 4;  $\text{R}^2$  represents a group selected from substituted or unsubstituted hydrocarbon groups having 1 to 12 carbon atoms and substituted or unsubstituted alkoxy groups having 1 to 12 carbon atoms and the groups  $\text{R}^2$  may be the same as or different from each other; and  $m$  is an integer of 0 to 6).

Examples of the epoxy resins represented by the Formula (I) include the epoxy resins from the monomer represented by the following Formula (IV) to (XXII), and the like.

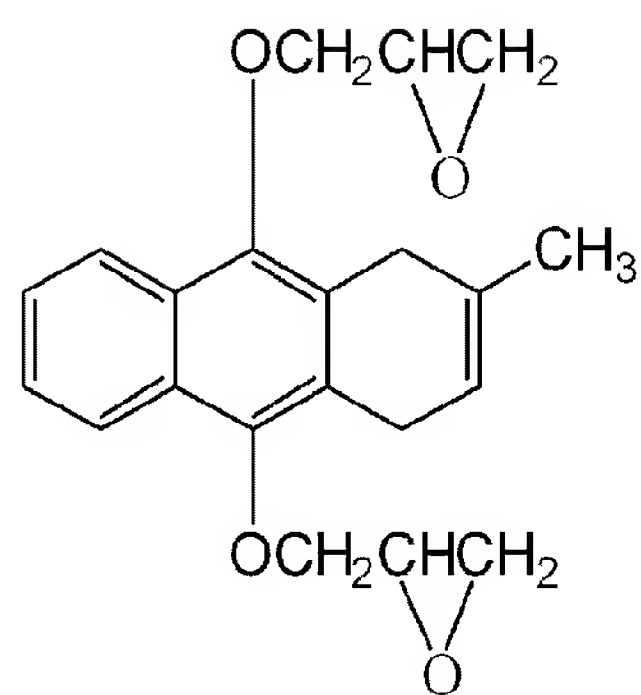
20 [0013]

[Formula 5]

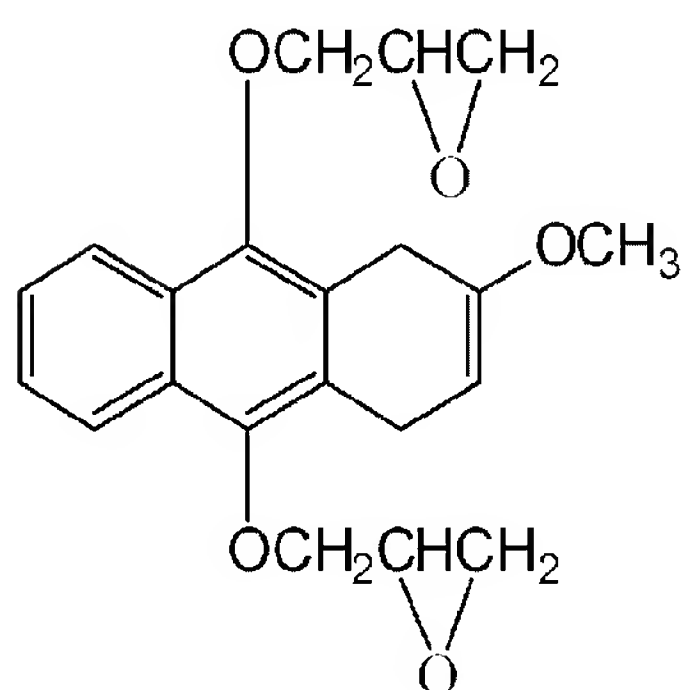




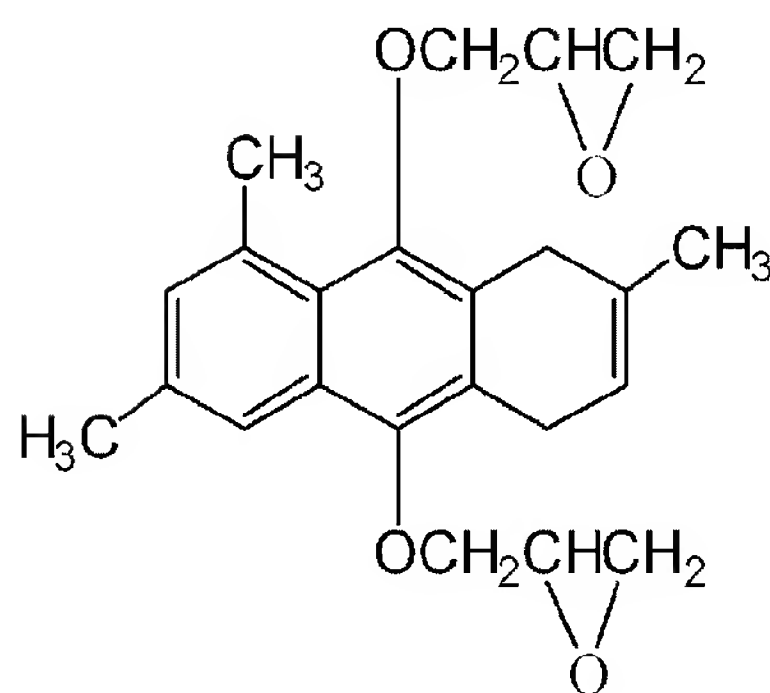
(XII)



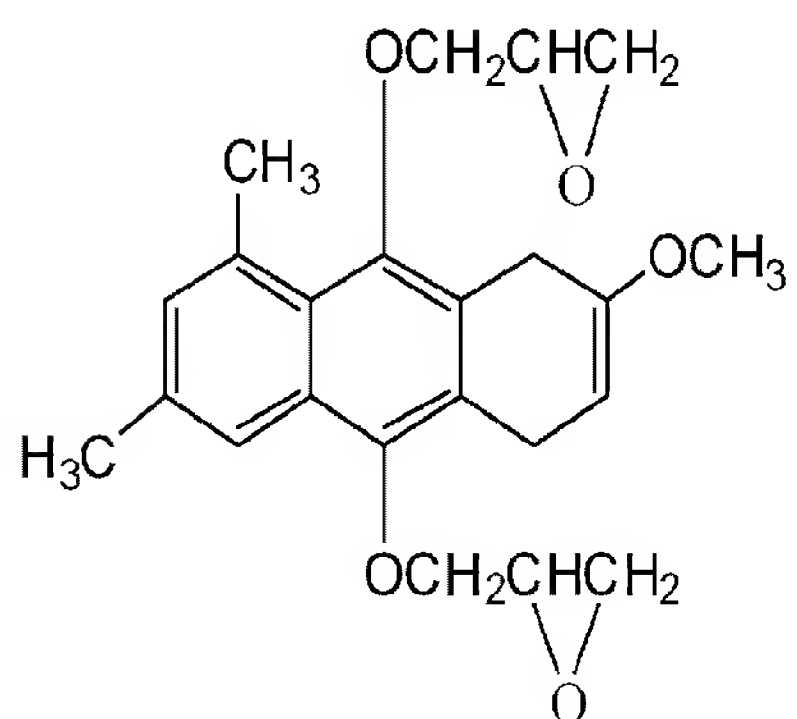
(XIII)



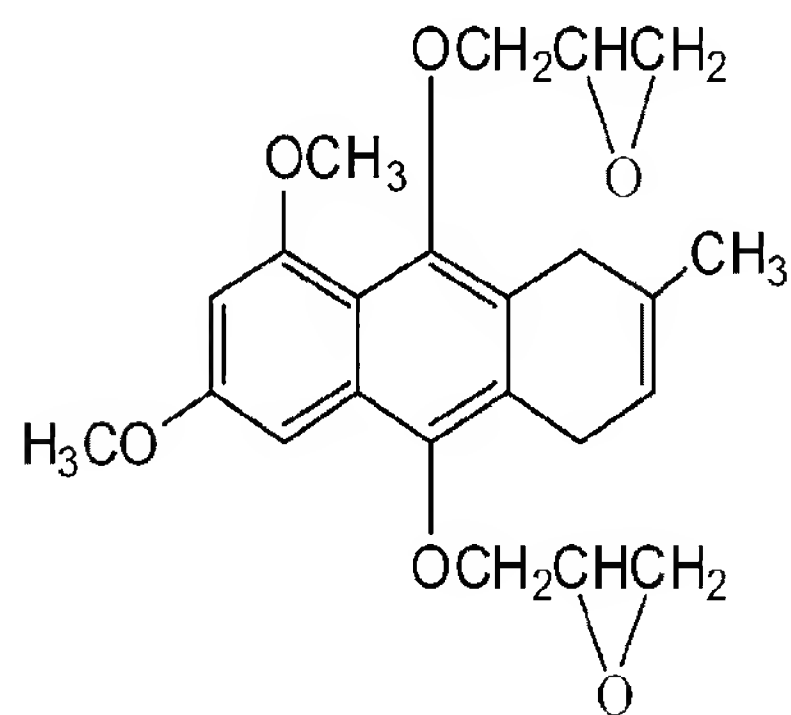
(XIV)



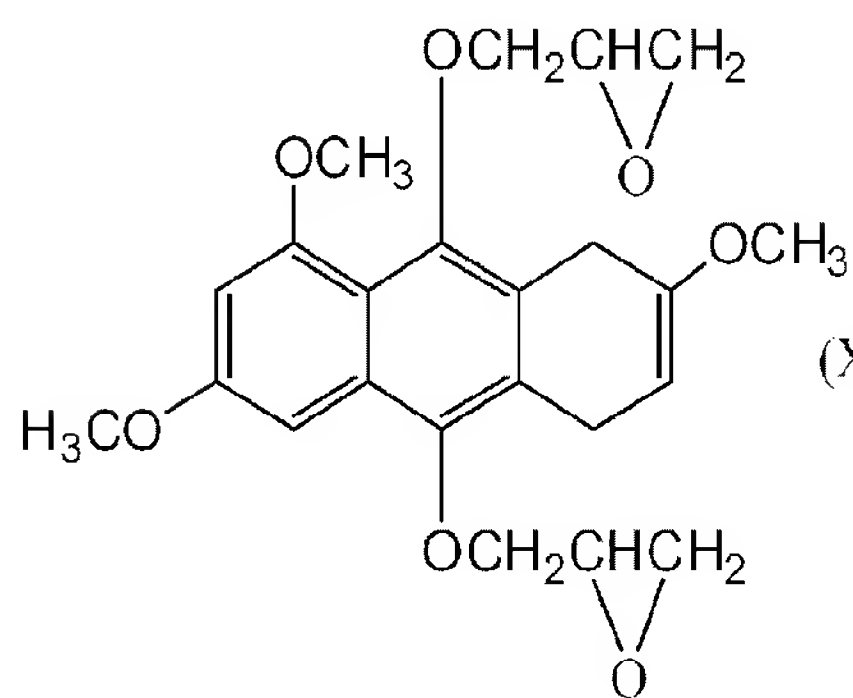
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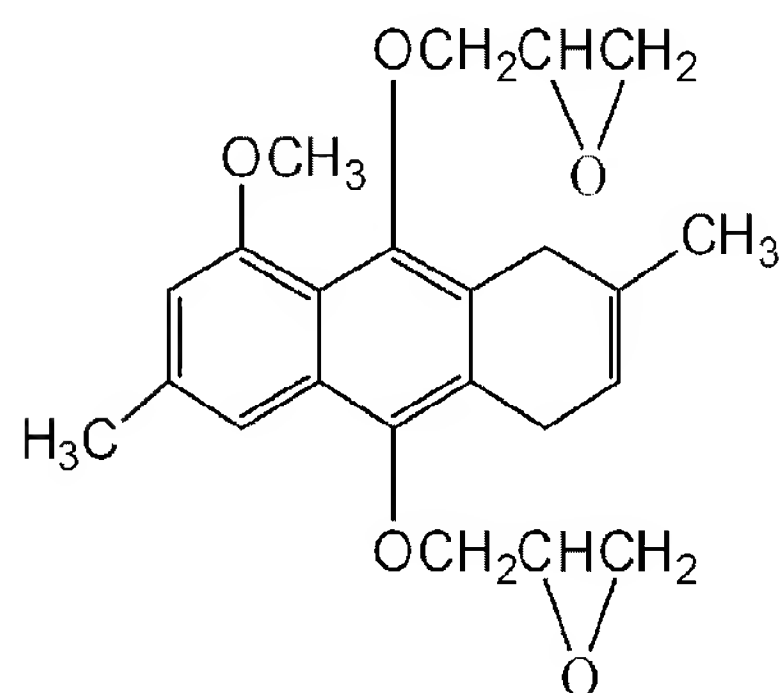
(XVI)



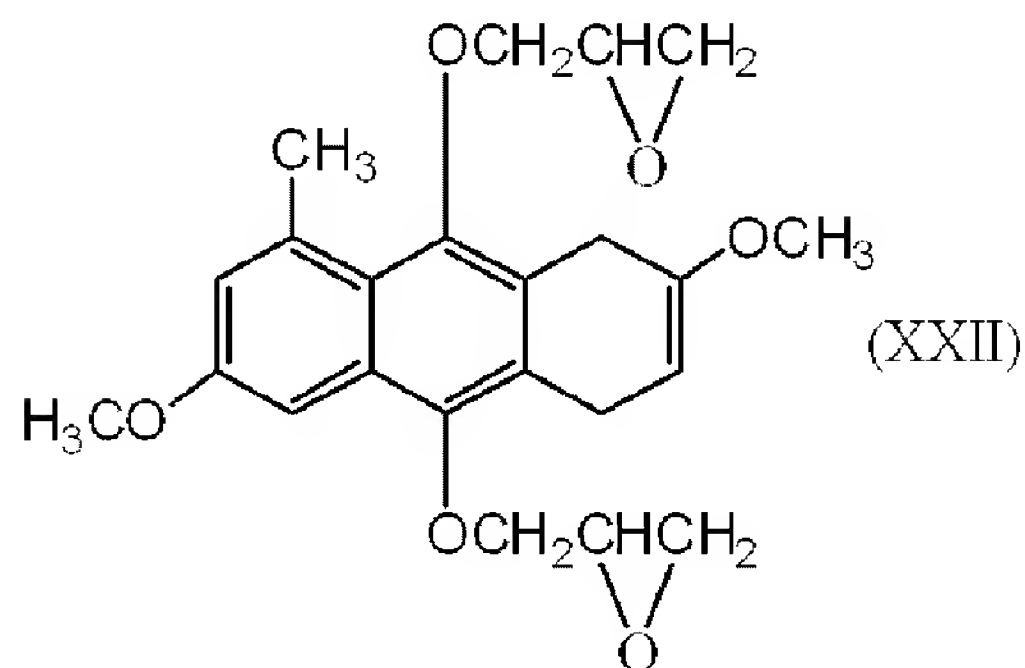
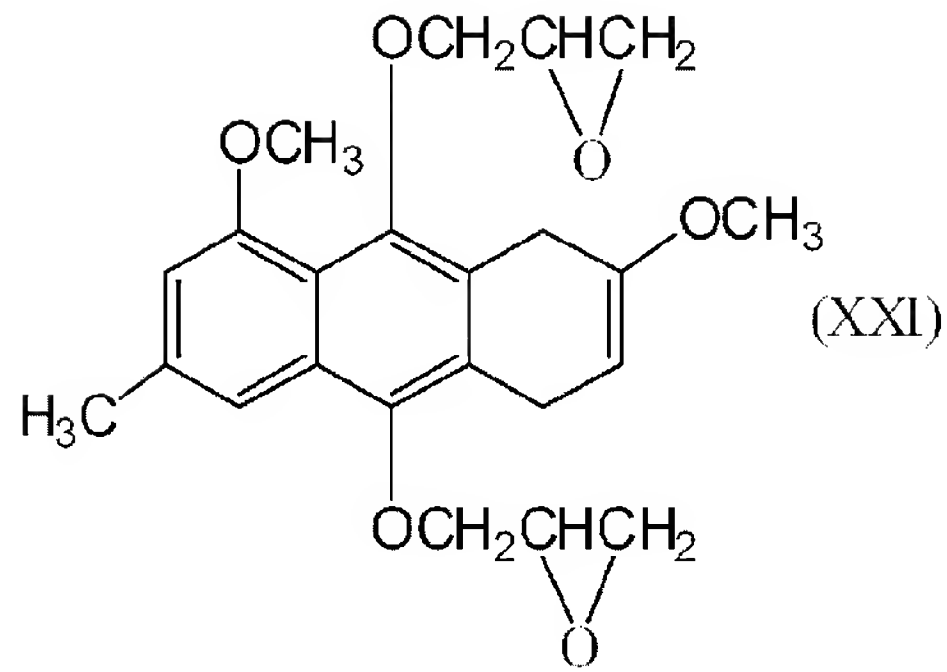
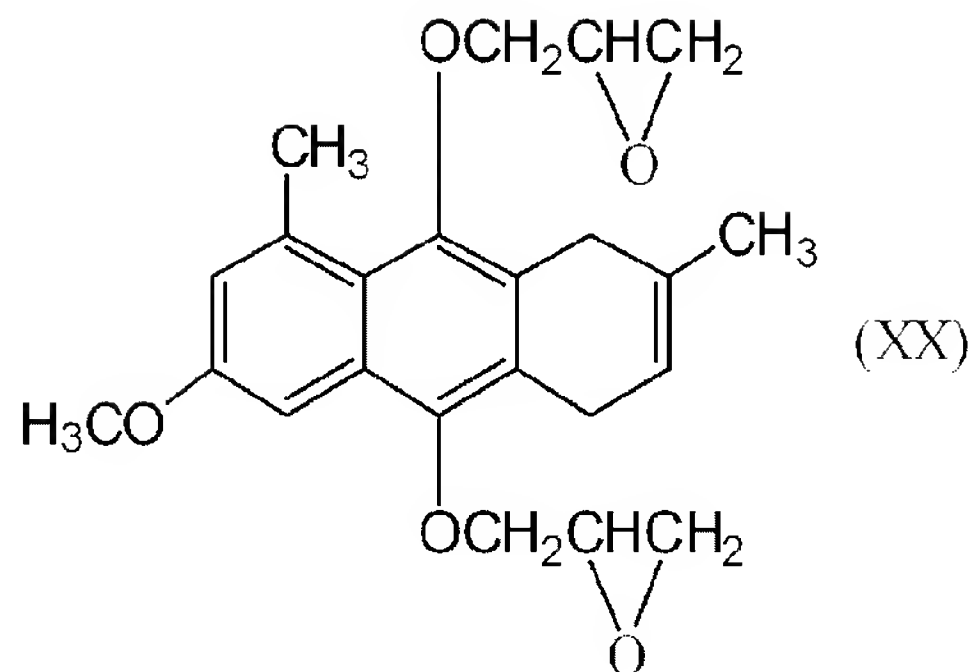
(XVII)



(XVIII)



(XIX)



Among the resins, the epoxy resins from the monomer represented by Formula (IV) are preferable, from the viewpoints of flame resistance and moldability. Commercially available products of such resins include YL-7172 (trade name, manufactured by Japan Epoxy Resin Co., Ltd.) and the like.

The blending rate of the epoxy resin represented by the General Formula (I) is preferably 30 wt % or more, more preferably 50 wt % or more, and still more preferably 60 wt % or more, with respect to the total amount of the epoxy resin, for making the resin show its favorable properties.

[0014]

The sealant epoxy-resin molding material according to the present invention may contain another known epoxy resin as needed. Examples of the epoxy resins for use include epoxidized novolak resins prepared from a novolak resin obtained by condensation or



cocondensation of a phenol such as phenol, cresol, xyleneol, resorcin, catechol, bisphenol A, or bisphenol F, and/or a naphthol such as  $\alpha$ -naphthol,  $\beta$ -naphthol, or dihydroxynaphthalene, with an aldehyde group-containing compound such as formaldehyde, acetaldehyde, propionaldehyde, benzaldehyde, or salicylic aldehyde in the presence of an acidic catalyst, including phenolic novolak epoxy resins, ortho-cresol novolak epoxy resins, and triphenylmethane skeleton-containing epoxy resins; diglycidyl ethers of bisphenol A, bisphenol F, bisphenol S, and alkyl-substituted or unsubstituted bisphenols, and the like; stilbene-based epoxy resins, hydroquinone-based epoxy resins, glycidyl ester-based epoxy resins obtained in reaction of epichlorohydrin and a polybasic acid such as phthalic acid or dimer acid, glycidylamine-based epoxy resins obtained in reaction of epichlorohydrin and a polyamine such as diaminodiphenylmethane or isocyanuric acid, epoxides of cocondensation resins of dicyclopentadiene and a phenol, naphthalene ring-containing epoxy resins, epoxides of aralkyl-based phenol resins such as xylylene or biphenylene skeleton-containing phenol-aralkyl resin and naphthol-aralkyl resin, trimethylolpropane-based epoxy resins, terpene-modified epoxy resins, linear aliphatic epoxy resins obtained by oxidizing olefin bonds with a peracid such as peracetic acid, alicyclic epoxy resins, sulfur atom-containing epoxy resins, and the like, and these resins may be used alone or in combination of two or more.

[0015]

Among them, biphenyl-based, bisphenol F-based,

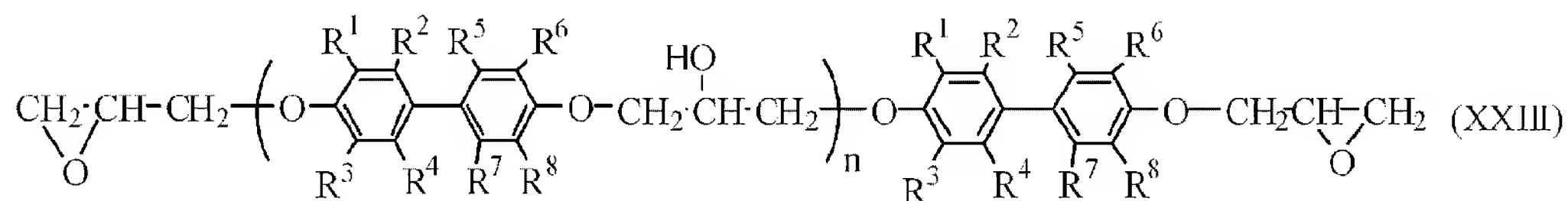
stilbene-based and sulfur atom-containing epoxy resins are preferable from the viewpoints of flowability and reflow resistance; novolak epoxy resins are preferable from the viewpoint of hardening efficiency; dicyclopentadiene-based epoxy resins are preferable from the viewpoint of low hygroscopicity; and naphthalene-based and triphenylmethane-based epoxy resins are preferable from the viewpoints of heat resistance and warpage resistance. The sealant epoxy-resin molding material according to the present invention preferably contains at least one of these epoxy resins additionally.

[0016]

Examples of the biphenyl-based epoxy resins include the epoxy resins represented by the following General Formula (XXIII) and the like; examples of the bisphenol F-based epoxy resins include the epoxy resins represented by the following General Formula (XXIV) and the like; examples of the stilbene-based epoxy resins include the epoxy resins represented by the following General Formula (XXV) and the like; and examples of the sulfur atom-containing epoxy resins include the epoxy resins represented by the following General Formula (XXVI) and the like.

[0017]

[Formula 6]

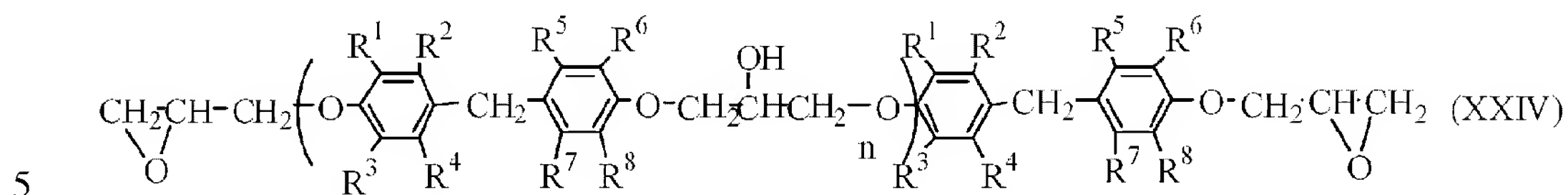


(wherein,  $\text{R}^1$  to  $\text{R}^8$  each represent a group selected from a hydrogen atom and substituted or unsubstituted monovalent

hydrocarbon groups having 1 to 10 carbon atoms and may be the same or different from each other; and n is an integer of 0 to 3).

[0018]

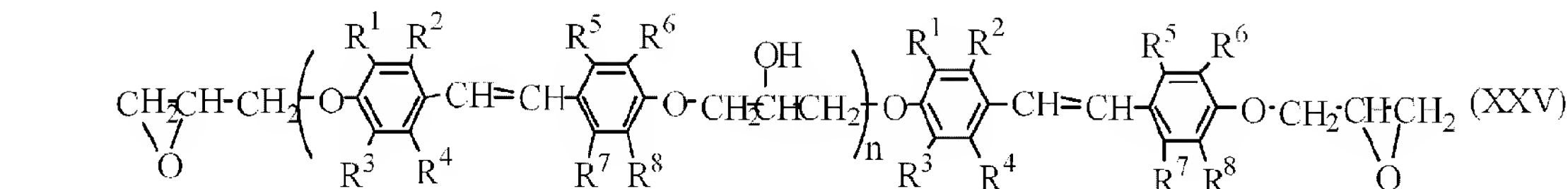
[Formula 7]



(wherein, R<sup>1</sup> to R<sup>8</sup> each represent a group selected from a hydrogen atom, alkyl group having 1 to 10 carbon atoms, alkoxyl groups having 1 to 10 carbon atoms, aryl groups having 6 to 10 carbon atoms, and aralkyl groups having 6 to 10 carbon atoms and may be the same or different from each other; and n is an integer of 0 to 3).

[0019]

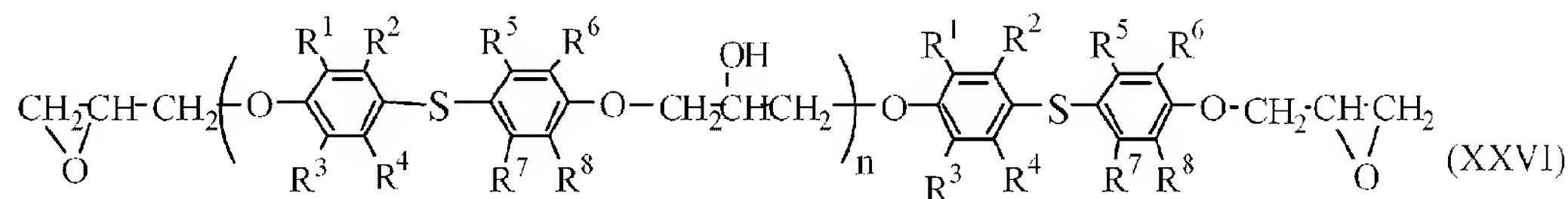
[Formula 8]



(wherein, R<sup>1</sup> to R<sup>8</sup> each represent a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon groups having 1 to 5 carbon atoms and may be the same or different from each other; and n is an integer of 0 to 10).

[0020]

20 [Formula 9]



(wherein,  $R^1$  to  $R^8$  each represent a group selected from a hydrogen atom, substituted or unsubstituted alkyl groups having 1 to 10 carbon atoms, and substituted or unsubstituted alkoxy groups having 1 to 10 carbon atoms and may be the same or different from each other; and  $n$  is an integer of 0 to 3).

[0021]

Examples of the biphenyl-based epoxy resins represented by General Formula (XXIII) include epoxy resins containing 4,4'-bis(2,3-epoxypropoxy) biphenyl or 4,4'-bis(2,3-epoxypropoxy)-3,3',5,5'-tetramethylbiphenyl as the principal component; epoxy resins prepared in reaction of epichlorohydrin and 4,4'-biphenol or 4,4'-(3,3',5,5'-tetramethyl) biphenol; and the like. Among them, epoxy resins containing 4,4'-bis(2,3-epoxypropoxy)-3,3',5,5'-tetramethylbiphenyl as the principal component are preferable. Commercially available products thereof include YX-4000 (trade name, manufactured by Japan Epoxy Resin Co., Ltd.) and the like.

[0022]

For example, resins containing the bisphenol F-based epoxy resin represented by General Formula (XXIV), wherein  $R^1$ ,  $R^3$ ,  $R^6$  and  $R^8$  are methyl groups,  $R^2$ ,  $R^4$ ,  $R^5$  and  $R^7$  are hydrogen atoms, and  $n=0$ , as the principal component, such as YSLV-80XY (trade name, manufactured by Tohto Kasei Co., Ltd.), are available on the market.

[0023]

Stilbene-based epoxy resin represented by General Formula (XXV) can be prepared in reaction of a raw material stilbene-based

phenol and epichlorohydrin in the presence of a basic substance.

Examples of the raw stilbene-based phenols include

3-tert-butyl-4,4'-dihydroxy-3',5,5'-trimethylstilbene,

3-tert-butyl-4,4'-dihydroxy-3',5',6-trimethylstilbene,

5 4,4'-dihydroxy-3,3',5,5'-tetramethylstilbene,

4,4'-dihydroxy-3,3'-di-tert-butyl-5,5'-dimethylstilbene,

4,4'-dihydroxy-3,3'-di-tert-butyl-6,6'-dimethylstilbene, and

the like; and, among them,

3-tert-butyl-4,4'-dihydroxy-3',5,5'-trimethylstilbene and

10 4,4'-dihydroxy-3,3',5,5'-tetramethylstilbene are preferable.

These stilbene-based phenols may be used alone or in combination of two or more.

[0024]

Among the sulfur atom-containing epoxy resins represented  
15 by General Formula (XXVI), epoxy resins in which  $R^2$ ,  $R^3$ ,  $R^6$  and  $R^7$  are hydrogen atoms and  $R^1$ ,  $R^4$ ,  $R^5$  and  $R^8$  are alkyl groups are preferable; and epoxy resins in which  $R^2$ ,  $R^3$ ,  $R^6$  and  $R^7$  are hydrogen atoms,  $R^1$  and  $R^8$  are tert-butyl groups, and  $R^4$  and  $R^5$  are methyl groups are more preferable. Commercially available products of  
20 such compounds include YSLV-120TE (trade name, manufactured by Tohto Kasei Co., Ltd.) and the like.

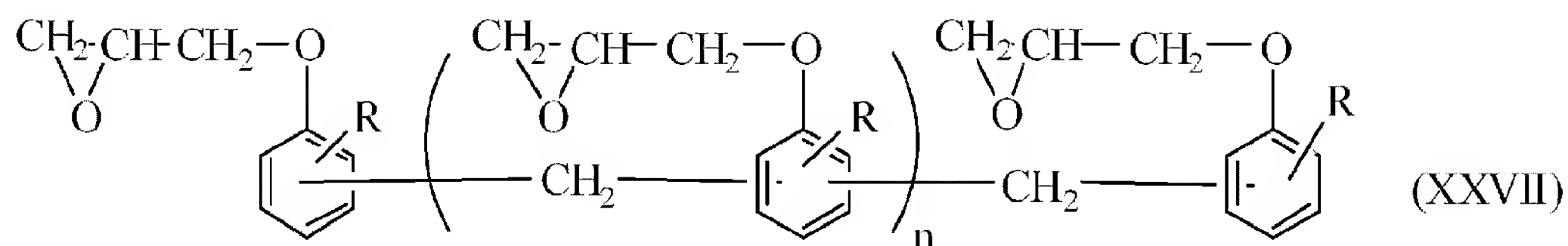
These epoxy resins may be used alone or in combination of two or more.

[0025]

25 Examples of the novolak epoxy resins include the epoxy resins represented by the following General Formula (XXVII) and the like.

[0026]

[Formula 10]



(wherein, R is a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon groups having 1 to 10 carbon atoms; and n is an integer of 0 to 10).

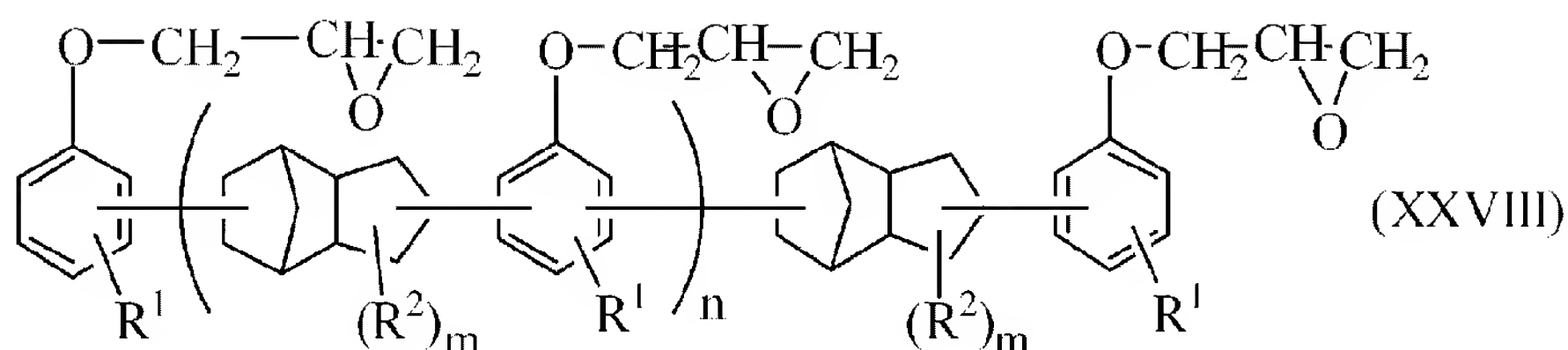
The novolak epoxy resin represented by General Formula (XXVII) can be prepared easily in reaction of a novolak phenol resin with epichlorohydrin. R in General Formula (XXVII) is preferably an alkyl group having 1 to 10 carbon atoms such as methyl, ethyl, propyl, butyl, isopropyl, or isobutyl, or an alkoxyl group having 1 to 10 carbon atoms such as methoxy, ethoxy, propoxy, or butoxy, and more preferably a hydrogen atom or a methyl group. n is preferably an integer of 0 to 3. o-Cresol novolak epoxy resins are preferable among the novolak epoxy resins represented by General Formula (XXVII). Commercially available products of such compounds include ESCN-190 (trade name, manufactured by Sumitomo Chemical Co., Ltd.) and the like.

[0027]

Examples of the dicyclopentadiene-based epoxy resins include the epoxy resins represented by the following General Formula (XXVIII) and the like.

[0028]

[Formula 11]



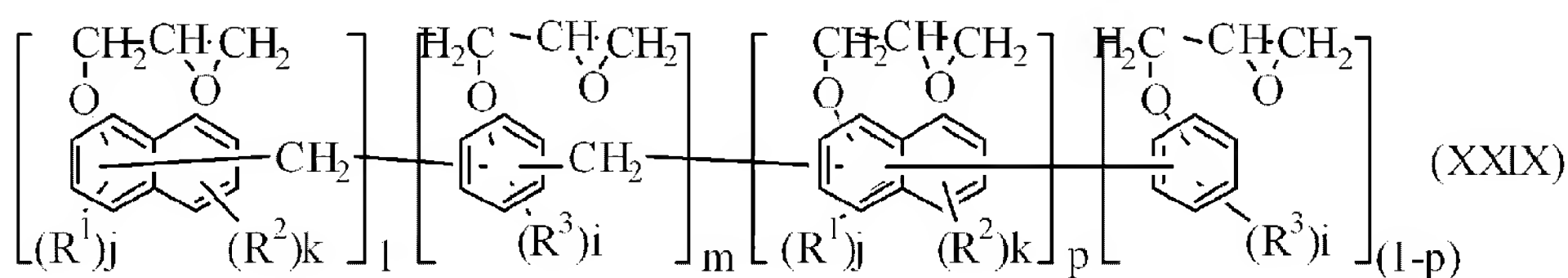
(wherein,  $R^1$  and  $R^2$  each independently represent a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon group having 1 to 10 carbon atoms;  $n$  is an integer of 0 to 10; and  $m$  is an integer of 0 to 6).

Examples of the group  $R^1$  in Formula (XXVIII) include a hydrogen atom; alkyl groups such as methyl, ethyl, propyl, butyl, isopropyl, and tert-butyl; alkenyl groups such as vinyl, allyl, and butenyl; and substituted or unsubstituted monovalent hydrocarbon group having 1 to 5 carbon atoms such as alkyl halide groups, amino group-substituted alkyl groups, and mercapto group-substituted alkyl groups; among them, alkyl groups such as methyl and ethyl and a hydrogen atom are preferable; and a methyl group and a hydrogen atom are more preferable. Examples of the group  $R^2$  include a hydrogen atom; alkyl groups such as methyl, ethyl, propyl, butyl, isopropyl, and tert-butyl; alkenyl groups such as vinyl, allyl, and butenyl; and substituted or unsubstituted monovalent hydrocarbon group having 1 to 5 carbon atoms such as alkyl halide groups, amino group-substituted alkyl groups, and mercapto group-substituted alkyl groups; and among them, a hydrogen atom is preferable. Commercially available products of such compounds include HP-7200 (trade name, manufactured by Dainippon Ink and Chemicals, Inc.) and the like.

Examples of the naphthalene-based epoxy resins include the epoxy resins represented by the following General Formula (XXIX) and the like; and examples of the triphenylmethane-based epoxy resins include those represented by the following General Formula (XXX) and the like.

[0030]

[Formula 12]



(wherein,  $R^1$  to  $R^3$  each represent a group selected from a

hydrogen atom and substituted or unsubstituted monovalent hydrocarbon group having 1 to 12 carbon atoms and may be the same or different from each other;  $p$  is 1 or 0; and each of  $l$  and  $m$  is an integer of 0 to 11 satisfying the conditions that  $(l+m)$  is an integer of 1 to 11 and  $(l+p)$  is an integer of 1 to 12;  $i$  is an integer of 0 to 3;  $j$  is an integer of 0 to 2; and  $k$  is an integer of 0 to 4).

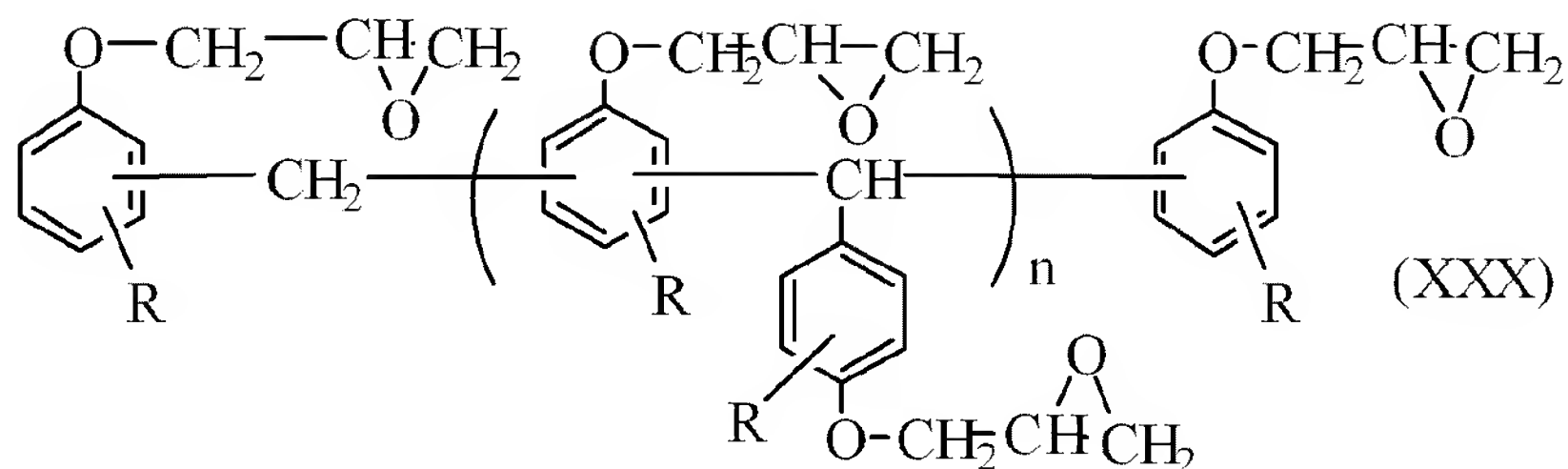
Examples of the naphthalene-based epoxy resins represented by General Formula (XXIX) include random copolymers containing  $l$  constituent unit and  $m$  other constituent units randomly, alternating copolymers containing them alternately, ordered copolymers containing them orderly, and block copolymers containing them blockwise; and these resins may be used alone or in combination of two or more. The compounds in which  $R^1$  and  $R^2$  are hydrogen atom and  $R^3$  is a methyl group are available on the market as NC-7000 (trade name, manufactured by Nippon Kayaku Co.,



Ltd.) and others.

[0031]

[Formula 13]



5            (wherein, R is a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon groups having 1 to 10 carbon atoms; and n is an integer of 1 to 10).

Compounds in which R is a hydrogen atom are available on the market as E-1032 (trade name, manufactured by Japan Epoxy Resin Co., Ltd.) and others.

These epoxy resins may be used alone or in combination of both of them.

[0032]

The hardening agent (B) for use in the present invention is not particularly limited, if it is commonly used in sealant epoxy-resin molding materials. Examples thereof include novolak phenol resins prepared in condensation or cocondensation of a phenol such as phenol, cresol, resorcin, catechol, bisphenol A, bisphenol F, phenylphenol, or aminophenol, and/or a naphthol such as  $\alpha$ -naphthol,  $\beta$ -naphthol, or dihydroxynaphthalene, with an aldehyde group-containing compound such as formaldehyde, benzaldehyde, or salicylic aldehyde in the presence of an acidic catalyst, aralkyl-based phenol resins prepared from phenols and/or

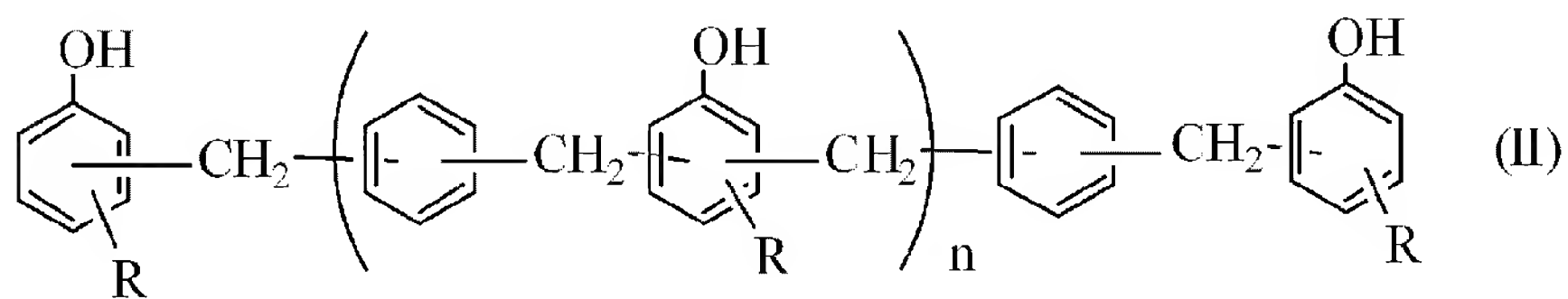
naphthols and dimethoxy-p-xylene or bis(methoxymethyl)biphenyl, such as phenol-aralkyl resins, biphenylene-based phenol-aralkyl resins, and naphthol-aralkyl resin, dicyclopentadiene-based phenol resin prepared in copolymerization of phenols and/or naphthols and dicyclopentadiene, such as dicyclopentadiene-based phenolic novolak resins and dicyclopentadiene-based naphthol novolak resins, triphenylmethane-based phenol resins, terpene-modified phenol resins, para-xylylene and/or meta-xylylene-modified phenol resins, melamine-modified phenol resins, cyclopentadiene-modified phenol resins, phenol resins prepared by copolymerization of two or more of the resins above, and the like. These resins may be use alone or in combination of two or more.

[0033]

Among them, the phenol-aralkyl resins represented by the following General Formula (II) are preferable from the viewpoints of flame resistance and moldability.

[0034]

[Formula 14]



(wherein, R is a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon groups having 1 to 10 carbon atoms; and n is an integer of 0 to 10).

Phenol-aralkyl resins in which R in General Formula (II) is a hydrogen atom and the average of n is 0 to 8 are more preferable.

Typical examples thereof include p-xylylene-based phenol-aralkyl resins, m-xylylene-based phenol-aralkyl resins, and the like. Commercially available products of such compounds include XLC (trade name, manufactured by Mitsui Chemicals, Inc.) and others.

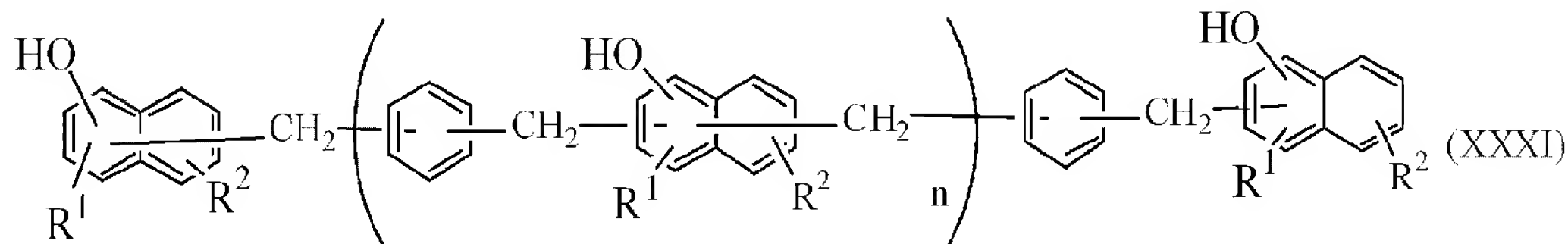
When one of these aralkyl-based phenol resins is used, the blending amount thereof is preferably 30 wt % or more, more preferably 50 wt % or more, with respect to the total amount of the hardening agents, for making the resin show its favorable properties.

[0035]

Examples of the naphthol-aralkyl resins include the phenol resins represented by the following General Formula (XXXI) and the like.

[0036]

[Formula 15]



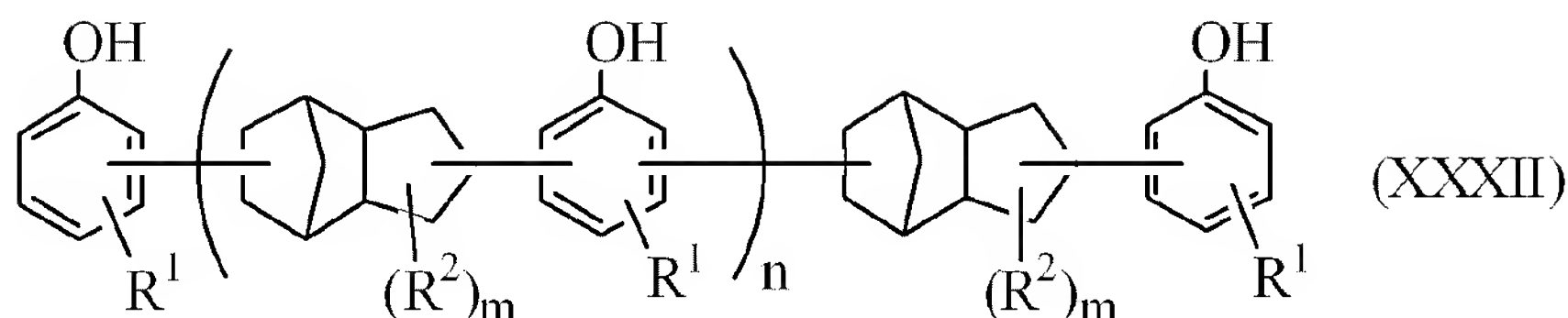
The naphthol-aralkyl resins represented by General Formula (XXXI) include the resins wherein all of R<sup>1</sup> and R<sup>2</sup> are hydrogen atoms and the like; and commercially available products of such compounds include SN-170 (trade name, manufactured by Nippon Steel Chemical Co., Ltd.).

[0037]

Examples of the dicyclopentadiene-based phenol resins include the phenol resins represented by the following General Formula (XXXII) and the like.

[0038]

[Formula 16]



(wherein,  $\text{R}^1$  and  $\text{R}^2$  each independently represent a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon group having 1 to 10 carbon atoms;  $n$  is an integer of 0 to 10; and  $m$  is an integer of 0 to 6).

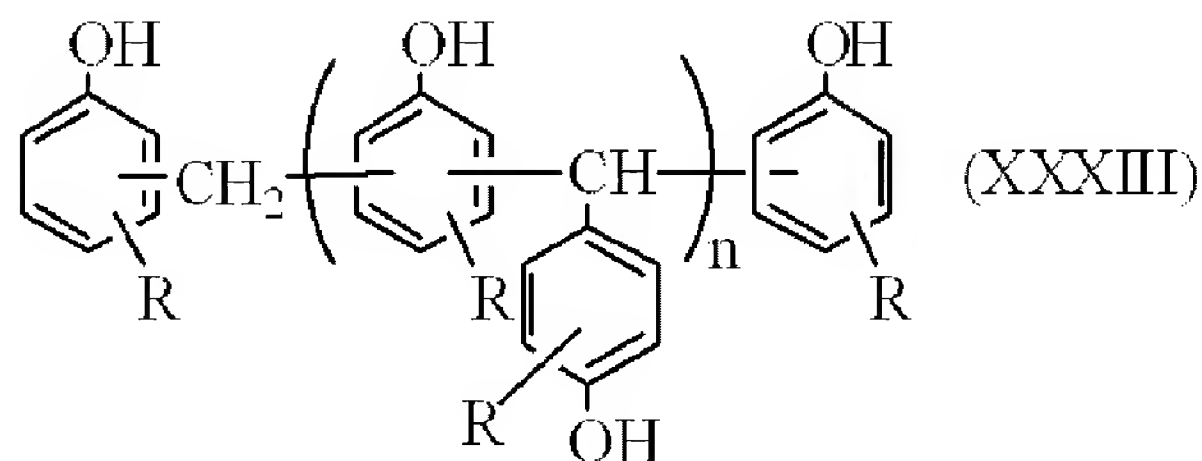
Compounds in which  $\text{R}^1$  and  $\text{R}^2$  are hydrogen atoms are available on the market, for example, as DPP (trade name, manufactured by Nippon Petrochemicals Co., Ltd.).

10 [0039]

Examples of the triphenylmethane-based phenol resins include the phenol resins represented by the following General Formula (XXXIII) and the like.

[0040]

15 [Formula 17]



(wherein,  $\text{R}$  is a group selected from a hydrogen atom and substituted or unsubstituted monovalent hydrocarbon groups having 1 to 10 carbon atoms, and  $n$  is an integer of 1 to 10).

20 Compounds in which  $\text{R}$  is a hydrogen atom are available as commercial products such as MEH-7500 (trade name, manufactured by Meiwa Plastic Industries, Ltd.).

[0041]

Examples of the novolak phenol resins include phenolic novolak resins, cresol novolak resins, naphthol novolak resins and the like; and among them, phenolic novolak resins are  
5 preferable.

[0042]

The phenol-aralkyl resins, naphthol-aralkyl resins, dicyclopentadiene-based phenol resins, triphenylmethane-based phenol resins, and novolak phenol resins may be used alone or in  
10 combination of two or more.

[0043]

The sealant epoxy-resin molding material according to the present invention may contain acenaphthylene for improvement in flame resistance. Acenaphthylene may be prepared by  
15 dehydrogenation of acenaphthene, or alternatively, a commercial product may be used. Yet alternatively, an acenaphthylenepolymer or a copolymer of acenaphthylene with another aromatic olefin may be used. The methods of preparing the acenaphthylene polymer or the copolymer of acenaphthylene with another aromatic olefin  
20 include radical, cationic, and anionic polymerizations, and the like. Any one of known catalysts may be used in polymerization, or alternatively, the polymerization may be performed only by heat without using a catalyst. The polymerization temperature then is preferably 80 to 160°C and more preferably 90 to 150°C. The  
25 softening temperature of the acenaphthylene polymer or the copolymer of acenaphthylene with another aromatic olefin obtained is preferably 60 to 150°C and more preferably 70 to 130°C. A

softening temperature lower than 60°C may lead to deterioration in moldability because of the exudation during molding, while that of higher than 150°C to deterioration in compatibility to the resin.  
[0044]

5           Examples of the other aromatic olefins copolymerized with acenaphthylene include styrene,  $\alpha$ -methylstyrene, indene, benzothiophene, benzofuran, vinyl naphthalene, vinylbiphenyl, the alkyl-substituted derivatives thereof, and the like. In addition to the aromatic olefin above, an aliphatic olefin may be used in  
10 combination in the range that does not impair the advantageous effects of the present invention. Examples of the aliphatic olefins include (meth)acrylic acid and the esters thereof, maleic anhydride, itaconic anhydride, fumaric acid and the esters thereof, and the like. The amount of the aliphatic olefin used is preferably  
15 20 wt % or less, more preferably 9 wt % or less, with respect to the total amount of the polymerization monomers.

[0045]

Acenaphthylene previously mixed with part or all of the hardening agent (B) may be used as the acenaphthylene.  
20 Alternatively, a previously prepared mixture of part or all of the hardening agent (B) with one or more of acenaphthylene, an acenaphthylene polymer, and a copolymer of acenaphthylene with another aromatic olefin may be used. The premixing methods include, for example, a method of pulverizing the hardening agent (B) and  
25 the acenaphthylene components respectively into fine particles and mixing them in the solid state, a method of dissolving these components in a high-solubility solvent uniformly and then removing

the solvent, a method of melt-mixing the hardening agent (B) and the acenaphthylene component at a temperature of the softening point of the hardening agent (B) and/or the acenaphthylene component or more, and the like; and the melting-mixing method  
5 is preferably, because it gives a mixture higher in uniformity and smaller in the amount of impurities. The temperature of melt-mixing is not particularly limited, if it is not lower than the softening temperatures of the hardening agent (B) and/or the acenaphthylene component, but is preferably 100 to 250°C and more  
10 preferably 120 to 200°C. The period of melt-mixing is also not particularly limited if the components are mixed uniformly, but preferably 1 to 20 hours and more preferably 2 to 15 hours.

[0046]

When the hardening agent (B) and acenaphthylene are premixed,  
15 the acenaphthylene component may polymerize or react with the hardening agent (B) during mixing. In the sealant epoxy-resin molding material according to the present invention, the premixture (acenaphthylene-modified hardening agent) described above is preferably contained in the hardening agent (B) in an amount of  
20 90 wt % or more, for improvement in the flame resistance due to the dispersibility of the acenaphthylene components. The content of acenaphthylene and/or the aromatic olefinic polymer including acenaphthylene in the acenaphthylene-modified hardening agent is preferably 5 to 40 wt % and more preferably 8 to 25 wt %. A content  
25 of less than 5 wt % may lead to deterioration in flame resistance, while a content of more than 40 wt % to deterioration in moldability. The content of the acenaphthylene structure in the epoxy resin

molding material according to the present invention is preferably 0.1 to 5 wt %, more preferably 0.3 to 3 wt %, from the viewpoints of flame resistance and moldability. A content of less than 0.1 wt % may lead to deterioration in flame resistance, while a content  
5 of more than 5 wt % to deterioration in moldability.

[0047]

The equivalence ratio of the epoxy resin (A) to the hardening agent (B), i.e., the ratio in number of the hydroxyl groups in hardening agent to the epoxy groups in epoxy resin (hydroxyl group  
10 number in hardening agent/epoxy group number in epoxy resin) is not particularly limited, but is preferably adjusted in the range of 0.5 to 2, more preferably 0.6 to 1.3, for reduction of the respective unreacted groups. It is more preferably adjusted in the range of 0.8 to 1.2, for obtaining a sealant epoxy-resin molding  
15 material superior in moldability and reflow resistance.

[0048]

The sealant epoxy-resin molding material according to the present invention may contain a hardening accelerator (C) as needed for acceleration of the reaction between epoxy resin (A) and  
20 hardening agent (B). The hardening accelerator (C) is not particularly limited if it is commonly used in sealant epoxy-resin molding materials, and examples thereof include cycloamidine compounds such as 1,8-diaza-bicyclo(5,4,0)undecene-7,  
1,5-diaza-bicyclo(4,3,0)nonene, and  
25 5,6-dibutylamino-1,8-diaza-bicyclo(5,4,0)undecene-7; and intramolecular polarized compounds prepared by adding to the compound above with a  $\pi$  bond-containing compound such as maleic



anhydride, a quinone compound such as 1,4-benzoquinone,  
 2,5-toluquinone, 1,4-naphthoquinone, 2,3-dimethylbenzoquinone,  
 2,6-dimethylbenzoquinone,  
 2,3-dimethoxy-5-methyl-1,4-benzoquinone,  
 5 2,3-dimethoxy-1,4-benzoquinone, or phenyl-1,4-benzoquinone,  
 diazo phenylmethane or phenol resin; tertiary amines and the  
 derivatives thereof such as benzyldimethylamine, triethanolamine,  
 dimethylaminoethanol, and tris(dimethylaminomethyl)phenol;  
 imidazoles and the derivatives thereof such as 2-methylimidazole,  
 10 2-phenylimidazole, 2-phenyl-4-methylimidazole; phosphine  
 compounds such as tributylphosphine, methyldiphenylphosphine,  
 triphenylphosphine, tris(4-methylphenyl)phosphine,  
 diphenylphosphine, and phenylphosphine; and the intramolecular  
 polarized phosphorus compounds prepared by adding, to the phosphine  
 15 compounds above, a  $\pi$  bond-containing compound such as maleic  
 anhydride, the quinone compound above, or diazo phenylmethane or  
 phenol resin; tetraphenylboron salts and the derivatives thereof  
 such as tetraphenylphosphonium tetraphenyl borate,  
 triphenylphosphine tetraphenyl borate,  
 20 2-ethyl-4-methylimidazole tetraphenyl borate, and  
 N-methylmorpholine tetraphenyl borate; and the like, and these  
 compounds may be use alone or in combination of two or more.

Among them, triphenylphosphine is preferable from the  
 viewpoints of flame resistance and hardening efficiency; and  
 25 adducts of a tertiary phosphine compound and a quinone compound  
 are preferable from the viewpoints of flame resistance, hardening  
 efficiency, flowability and release characteristics. Favorable

examples of the tertiary phosphine compounds include, but are not limited to, tertiary phosphine compounds having alkyl or aryl groups such as tricyclohexylphosphine, tributylphosphine, dibutylphenylphosphine, butyl diphenylphosphine,

5 ethyldiphenylphosphine, triphenylphosphine,  
 tris(4-methylphenyl)phosphine, tris(4-ethylphenyl)phosphine,  
 tris(4-propylphenyl)phosphine, tris(4-butylphenyl)phosphine,  
 tris(isopropylphenyl)phosphine,  
 tris(tert-butylphenyl)phosphine,  
 10 tris(2,4-dimethylphenyl)phosphine,  
 tris(2,6-dimethylphenyl)phosphine,  
 tris(2,4,6-trimethylphenyl)phosphine,  
 tris(2,6-dimethyl-4-ethoxyphenyl)phosphine,  
 tris(4-methoxyphenyl)phosphine, tris(4-ethoxyphenyl)phosphine,  
 15 and the like. Examples of the quinone compounds include  
 o-benzoquinone, p-benzoquinone, diphenoquinone,  
 1,4-naphthoquinone, anthraquinone, and the like; and among them,  
 p-benzoquinone is preferable from the viewpoints of moisture  
 resistance and storage stability. An adduct of  
 20 tris(4-methylphenyl)phosphine and p-benzoquinone is more  
 preferable from the viewpoint of release characteristics.  
 [0049]

The blending amount of the hardening accelerator is not particularly limited, if it is sufficient for showing a  
 25 hardening-acceleration effect, but is preferably 0.005 to 2 wt %, more preferably 0.01 to 0.5 wt %, with respect to the sealant epoxy-resin molding material. An amount of less than 0.005 wt %

may lead to deterioration in short-term hardening efficiency, while an amount of more than 2 wt % to an excessive high hardening velocity, making it difficult to obtain a favorable molded product.

[0050]

5           In the present invention, an inorganic filler (D) may be blended as needed. Addition of an inorganic filler is effective in reducing hygroscopicity and linear expansion coefficient and in increasing heat conductivity and strength, and examples thereof include powders of fused silica, crystalline silica, alumina,  
10   zircon, calcium silicate, calcium carbonate, potassium titanate, silicon carbide, silicon nitride, aluminum nitride, boron nitride, beryllia, zirconia, zircon, forsterite, steatite, spinel, mullite, titania, and the like; the spherical beads thereof, glass fiber, and the like. Examples of the flame-retarding inorganic fillers  
15   include aluminum hydroxide, magnesium hydroxide, composite metal hydroxides, zinc borate, zinc molybdenate, and the like. Commercially available zinc borate products include FB-290 and FB-500 (manufactured by U.S. Borax), FRZ-500C (manufactured by Mizusawa Industrial Chemicals, Ltd.), and the like; and those of  
20   zinc molybdenate include KEMGARD 911B, 911C, and 1100 (manufactured by Sherwin-Williams) and the like.

          These inorganic fillers may be used alone or in combination of two or more. Among them, fused silica is preferable from the viewpoint of performance of filling and low linear expansion  
25   coefficient; alumina is preferable from the point of high heat conductivity; and the inorganic filler is preferably spherical in shape from the points of performance of filling and abrasion

to mold.

The amount of the inorganic filler blended is preferably 50 wt % or more with respect to the sealant epoxy-resin composition, from the viewpoints of flame resistance, moldability, low  
 5 hygroscopicity, low linear expansion coefficient, high strength and reflow resistance, preferably 60 to 95 wt % and still more preferably 70 to 90 wt %. An amount of less than 60 wt % may lead to deterioration in flame resistance and reflow resistance, while an amount of more than 95 wt % to insufficient flowability and  
 10 also to deterioration in flame resistance.

[0051]

When an inorganic filler (D) is used, a coupling agent (E) is preferably added to the sealant epoxy-resin molding material according to the present invention, for improvement in adhesiveness  
 15 between the resin components and the filler. The coupling agent (E) is not particularly limited if it is commonly used in sealant epoxy-resin molding materials, and examples thereof include various silane compounds such as primary, secondary and/or tertiary amino group-containing silane compounds, epoxysilanes,  
 20 mercaptosilanes, alkylsilanes, ureidosilanes, and vinylsilanes; titanium compounds, aluminum chelates, aluminum/zirconium compounds, and the like. Typical examples thereof include silane coupling agents such as vinyltrichlorosilane,  
 vinyltriethoxysilane, vinyltris( $\beta$ -methoxyethoxy)silane,  
 25  $\gamma$ -methacryloxypropyltrimethoxysilane,  
 $\beta$ -(3,4-epoxycyclohexyl)ethyltrimethoxysilane,  
 $\gamma$ -glycidoxypropyltrimethoxysilane,

- $\gamma$ -glycidoxypropylmethyldimethoxysilane, vinyltriacetoxysilane,  
 $\gamma$ -mercaptopropyltrimethoxysilane,  
 $\gamma$ -aminopropyltrimethoxysilane,  
 $\gamma$ -aminopropylmethyldimethoxysilane,  
5  $\gamma$ -aminopropyltriethoxysilane,  $\gamma$ -aminopropylmethyl  
diethoxysilane,  $\gamma$ -anilinopropyltrimethoxysilane,  
 $\gamma$ -anilinopropyltriethoxysilane,  
 $\gamma$ -(N,N-dimethyl)aminopropyltrimethoxysilane,  
 $\gamma$ -(N,N-diethyl)aminopropyltrimethoxysilane,  
10  $\gamma$ -(N,N-dibutyl)aminopropyltrimethoxysilane,  
 $\gamma$ -(N-methyl)anilinopropyltrimethoxysilane,  
 $\gamma$ -(N-ethyl)anilinopropyltrimethoxysilane,  
 $\gamma$ -(N,N-dimethyl)aminopropyltriethoxysilane,  
 $\gamma$ -(N,N-diethyl)aminopropyltriethoxysilane,  $\gamma$ -(N,N-dibutyl)  
15 aminopropyltriethoxysilane,  
 $\gamma$ -(N-methyl)anilinopropyltriethoxysilane,  
 $\gamma$ -(N-ethyl)anilinopropyltriethoxysilane,  
 $\gamma$ -(N,N-dimethyl)aminopropylmethyldimethoxysilane,  
 $\gamma$ -(N,N-diethyl)aminopropylmethyldimethoxysilane,  
20  $\gamma$ -(N,N-dibutyl)aminopropylmethyldimethoxysilane,  
 $\gamma$ -(N-methyl)anilinopropylmethyldimethoxysilane,  
 $\gamma$ -(N-ethyl)anilinopropylmethyldimethoxysilane,  
N-(trimethoxysilylpropyl)ethylenediamine,  
N-(dimethoxymethylsilylisopropyl)ethylenediamine,  
25 methyltrimethoxysilane, dimethyldimethoxysilane,  
methyltriethoxysilane,  $\gamma$ -chloropropyltrimethoxysilane,  
hexamethyldisilane, vinyltrimethoxysilane, and

$\gamma$ -mercaptopropylmethyldimethoxysilane; titanate coupling agents  
 such as isopropyl triisostearoyltitanate, isopropyl  
 tris(dioctylpyrophosphate) titanate, isopropyl  
 tri(N-aminoethyl-aminoethyl)titanate, tetraoctyl  
 5 bis(ditridecylphosphite) titanate,  
 tetra(2,2-diallyloxymethyl-1-butyl) bis(ditridecyl)phosphite  
 titanate, bis(dioctylpyrophosphate) oxyacetate titanate,  
 bis(dioctylpyrophosphato)ethylene titanate,  
 isopropyltrioctanoyl titanate, isopropyldimethacrylisostearoyl  
 10 titanate, isopropyltridodecyl benzenesulfonyl titanate,  
 isopropylisostearoyldiacryl titanate, isopropyl  
 tri(dioctylphosphate) titanate, isopropyltricumylphenyl  
 titanate, and tetraisopropyl bis(dioctylphosphite) titanate; and  
 the like, and these compounds may be use alone or in combination  
 15 of two or more.

[0052]

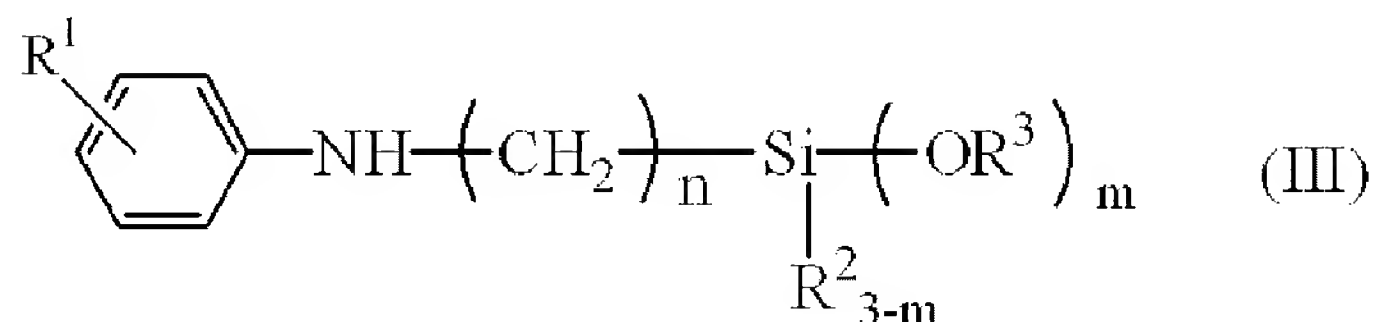
Among them, secondary amino group-containing  
 silane-coupling agents are preferable from the viewpoints of  
 flowability and flame resistance. The secondary amino  
 20 group-containing silane-coupling agent is not particularly  
 limited if it is a silane compound having a secondary amino group  
 in the molecule, and examples thereof include  
 $\gamma$ -anilinopropyltrimethoxysilane,  
 $\gamma$ -anilinopropyltriethoxysilane,  
 25  $\gamma$ -anilinopropylmethyldimethoxysilane,  
 $\gamma$ -anilinopropylmethyldiethoxysilane,  
 $\gamma$ -anilinopropylethyldiethoxysilane,

- $\gamma$ -anilinopropylethyldimethoxysilane,  
 $\gamma$ -anilinomethyltrimethoxysilane,  
 $\gamma$ -anilinomethyltriethoxysilane,  
 $\gamma$ -anilinomethylmethyldimethoxysilane,  
5  $\gamma$ -anilinomethylmethyldiethoxysilane,  
 $\gamma$ -anilinomethylethyldiethoxysilane,  
 $\gamma$ -anilinomethylethyldimethoxysilane,  
N-(p-methoxyphenyl)- $\gamma$ -aminopropyltrimethoxysilane,  
N-(p-methoxyphenyl)- $\gamma$ -aminopropyltriethoxysilane,  
10 N-(p-methoxyphenyl)- $\gamma$ -aminopropylmethyldimethoxysilane,  
N-(p-methoxyphenyl)- $\gamma$ -aminopropylmethyldiethoxysilane,  
N-(p-methoxyphenyl)- $\gamma$ -aminopropylethyldiethoxysilane,  
N-(p-methoxyphenyl)- $\gamma$ -aminopropylethyldimethoxysilane,  
 $\gamma$ -(N-methyl)aminopropyltrimethoxysilane,  
15  $\gamma$ -(N-ethyl)aminopropyltrimethoxysilane,  
 $\gamma$ -(N-butyl)aminopropyltrimethoxysilane,  
 $\gamma$ -(N-benzyl)aminopropyltrimethoxysilane,  
 $\gamma$ -(N-methyl)aminopropyltriethoxysilane,  
 $\gamma$ -(N-ethyl)aminopropyltriethoxysilane,  
20  $\gamma$ -(N-butyl)aminopropyltriethoxysilane,  
 $\gamma$ -(N-benzyl)aminopropyltriethoxysilane,  
 $\gamma$ -(N-methyl)aminopropylmethyldimethoxysilane,  
 $\gamma$ -(N-ethyl)aminopropylmethyldimethoxysilane,  
 $\gamma$ -(N-butyl)aminopropylmethyldimethoxysilane,  
25  $\gamma$ -(N-benzyl)aminopropylmethyldimethoxysilane,  
N- $\beta$ -(aminoethyl)- $\gamma$ -aminopropyltrimethoxysilane,  
 $\gamma$ -( $\beta$ -aminoethyl)aminopropyltrimethoxysilane,

N-β-(N-vinylbenzylaminoethyl)-γ-aminopropyltrimethoxysilane, and the like. Among them, particularly preferable are the aminosilane-coupling agents represented by the following General Formula (III):

5 [0053]

[Formula 18]



(wherein, R<sup>1</sup> represents a group selected from a hydrogen atom, alkyl groups having 1 to 6 carbon atoms, and alkoxy group  
10 having 1 to 2 carbon atoms; R<sup>2</sup> represents a group selected from alkyl group having 1 to 6 carbon atoms and a phenyl group; R<sup>3</sup> represents a methyl or ethyl group; n is an integer of 1 to 6; and m is an integer of 1 to 3).

[0054]

15 The total blending amount of the coupling agents is preferably 0.037 to 4.75 wt %, more preferably 0.05 to 5 wt %, and still more preferably 0.1 to 2.5 wt %, with respect to the sealant epoxy-resin composition. An amount of less than 0.037 wt % may lead to deterioration in the adhesiveness to frame, while  
20 an amount of more than 4.75 wt % to deterioration in package moldability.

[0055]

A known non-halogen, non-antimony flame retardant may be blended as needed in the sealant epoxy-resin molding material  
25 according to the present invention for further improvement in flame

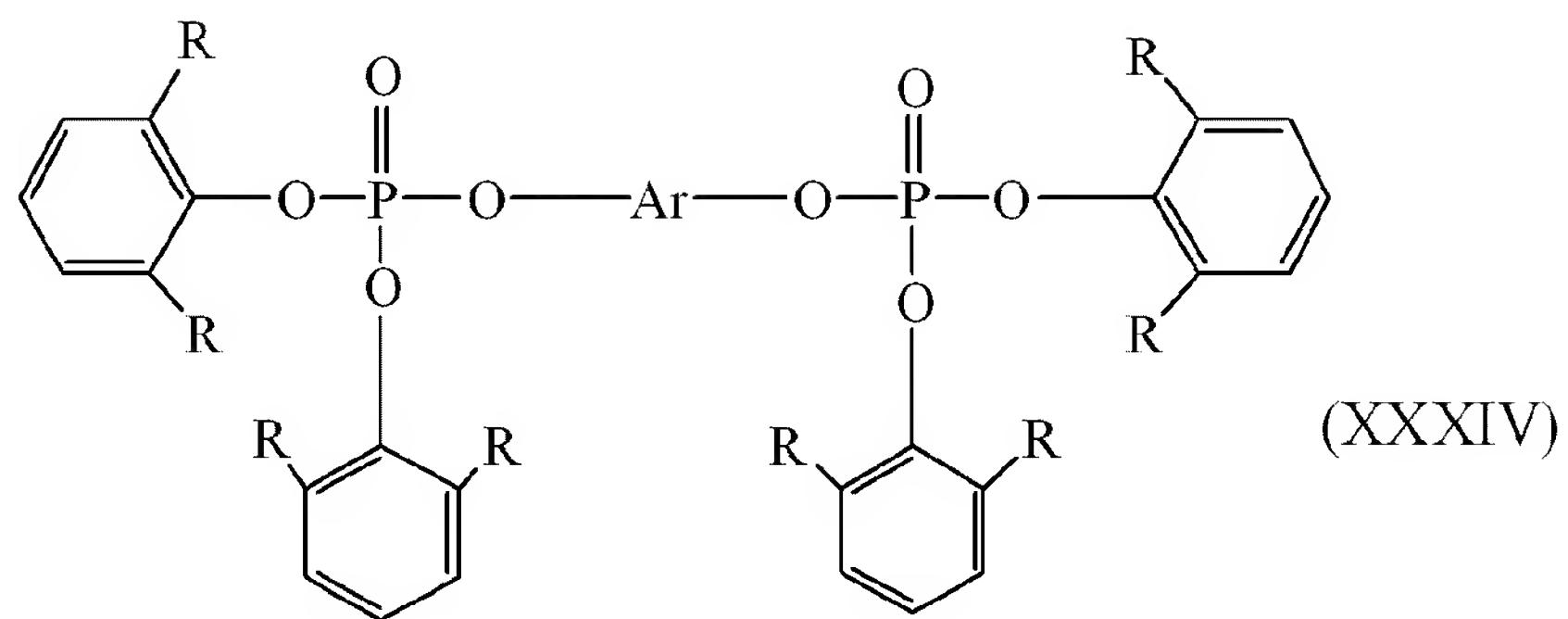


resistance. Examples thereof include phosphorus compounds such as red phosphorus, red phosphorus coated with an inorganic compound such as zinc oxide or a thermosetting resin such as phenol resin, phosphoric ester coated as above, and phosphine oxide; triazine  
5 ring-containing compounds such as melamine, melamine derivatives, and melamine-modified phenol resins; nitrogen-containing compounds such as cyanuric acid derivatives and isocyanuric acid derivatives; phosphorus and nitrogen-containing compounds such as cyclophosphazene; metal element-containing compounds such as  
10 aluminum hydroxide, magnesium hydroxide, composite metal hydroxides, zinc oxide, zinc stannate, zinc borate, iron oxide, oxidation molybdenum, zinc molybdenate, and dicyclopentadienyliron; and the like, and these compounds may be used alone or in combination of two or more.

15       Among them, phosphoric esters, phosphine oxide and cyclophosphazene are preferable, from the viewpoint of flowability. The phosphoric ester is not particularly limited if it is an ester compound from phosphoric acid and an alcohol or phenol compound, and examples thereof include trimethyl phosphate, triethyl  
20 phosphate, triphenyl phosphate, tricresyl phosphate, trixylenyl phosphate, cresyl diphenyl phosphate, xylenyl diphenyl phosphate, tris(2,6-dimethylphenyl) phosphate, condensed aromatic phosphoric esters, and the like. Among them, the condensed aromatic phosphoric esters represented by the following General  
25 Formula (XXXIV) are preferable from the viewpoint of hydrolysis resistance.

[0056]

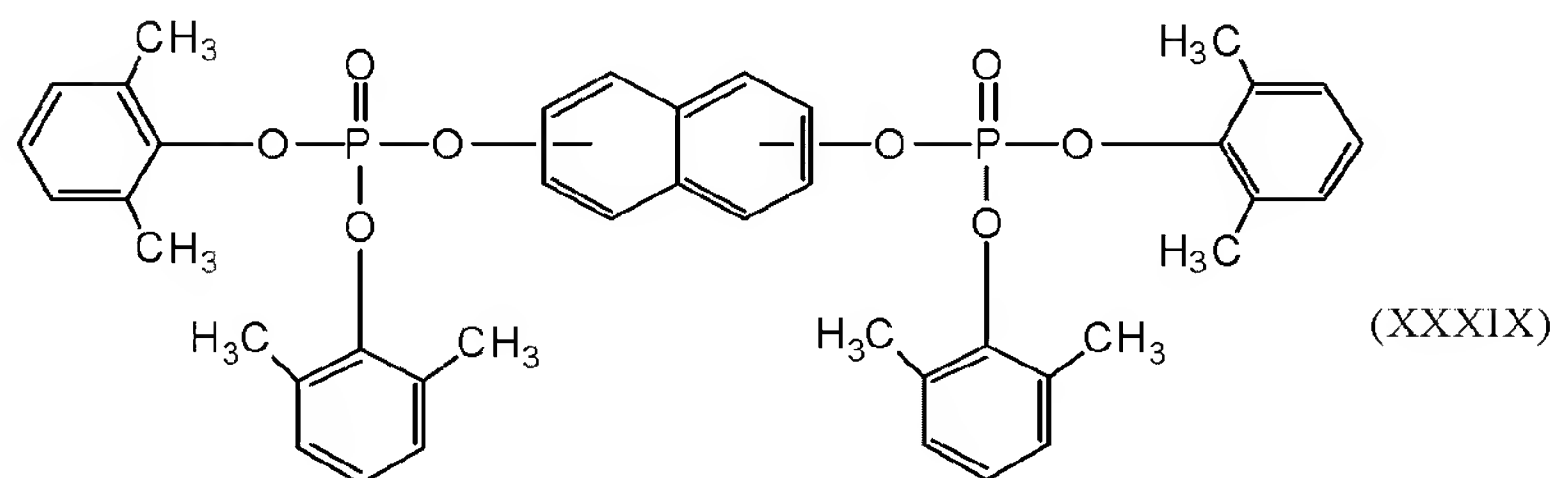
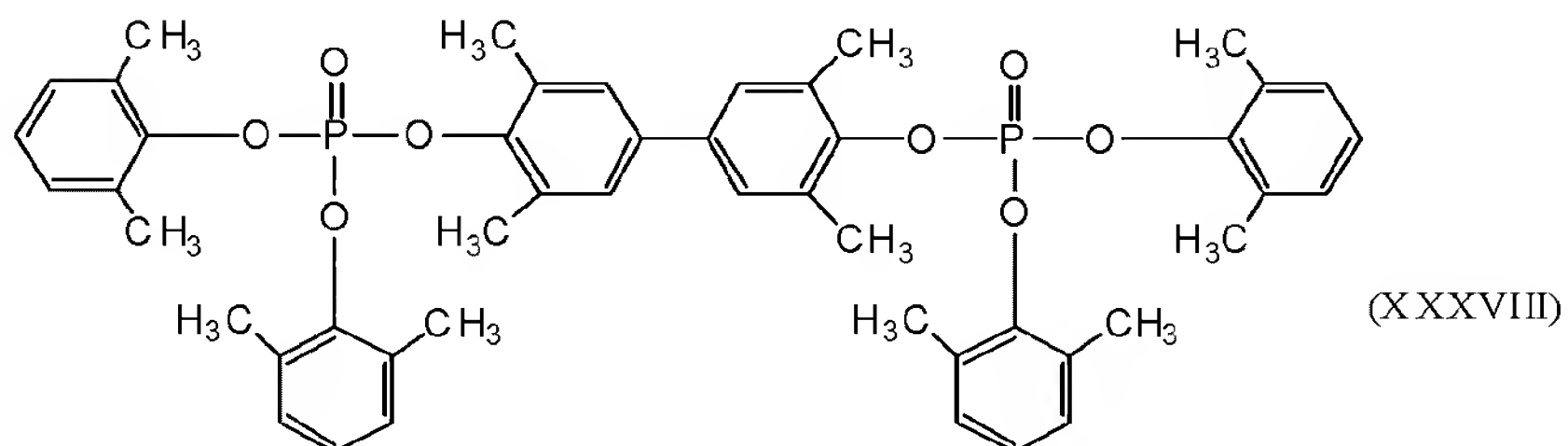
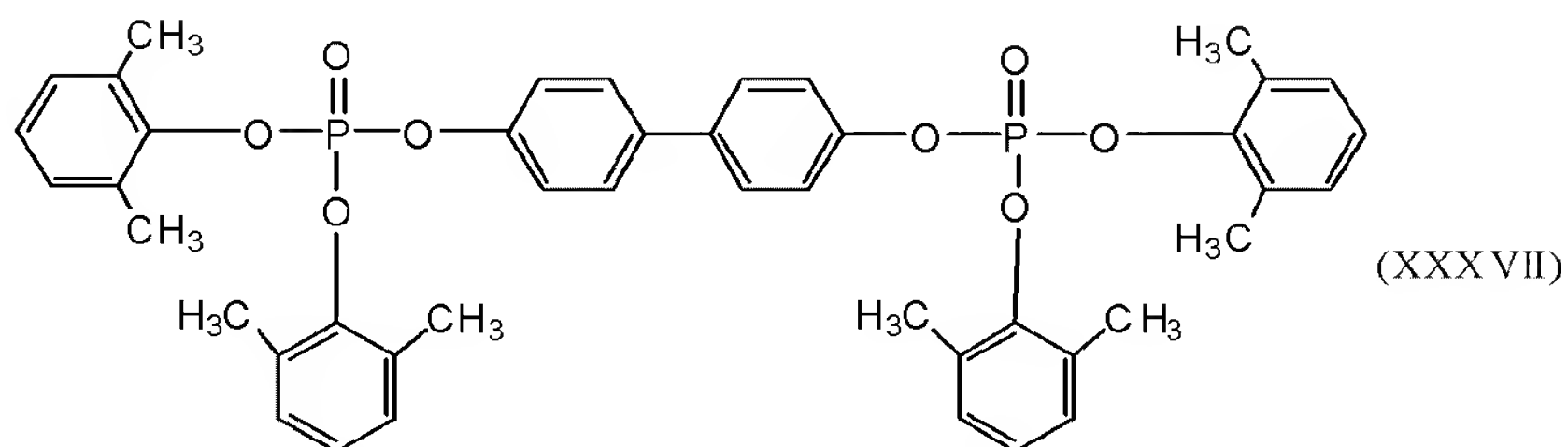
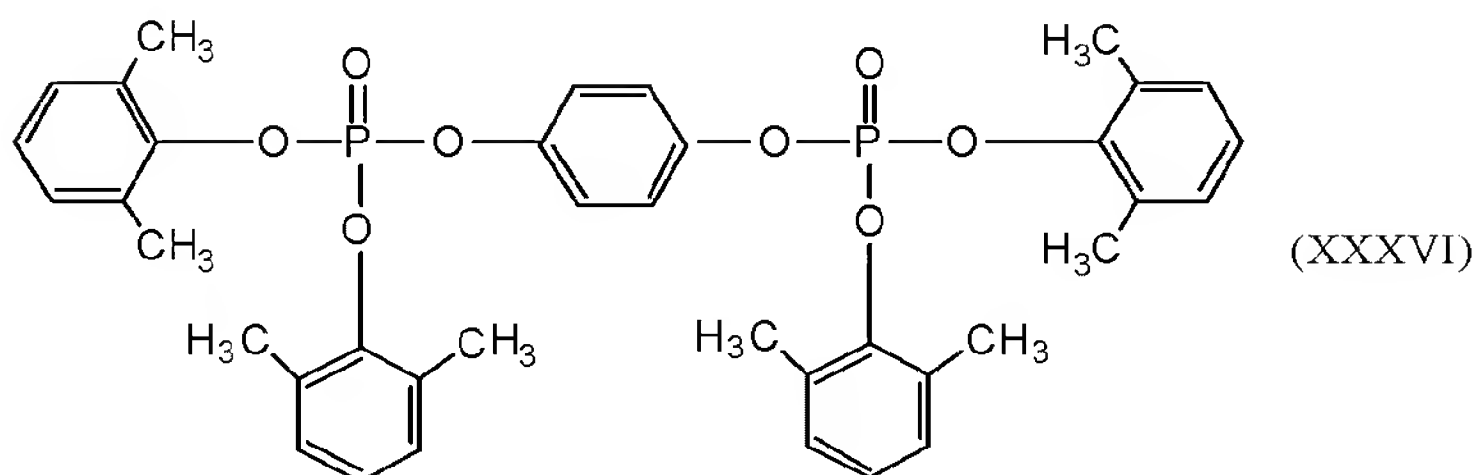
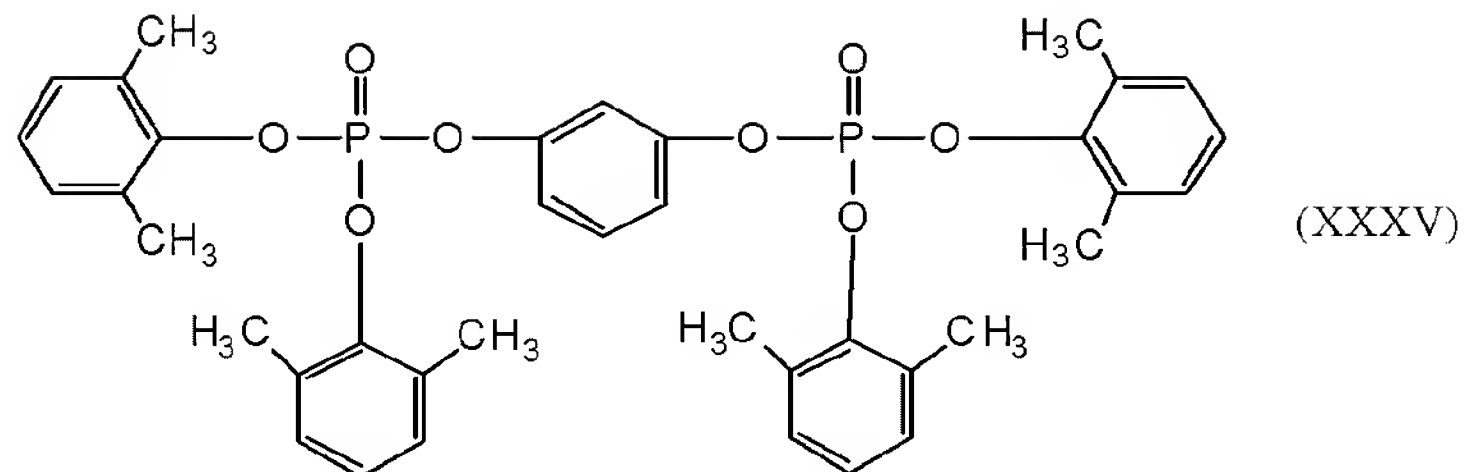
[Formula 19]



Examples of the phosphoric ester represented by Formula (XXXIV) above include the phosphoric esters represented by the following formulae (XXXV) to (XXXIX), and the like.

[0057]

[Formula 20]



[0058]

The amount of the phosphoric ester added is preferably in the range of 0.2 to 3.0 wt % as phosphorus atom with respect to the total amount of all components other than the filler. An amount

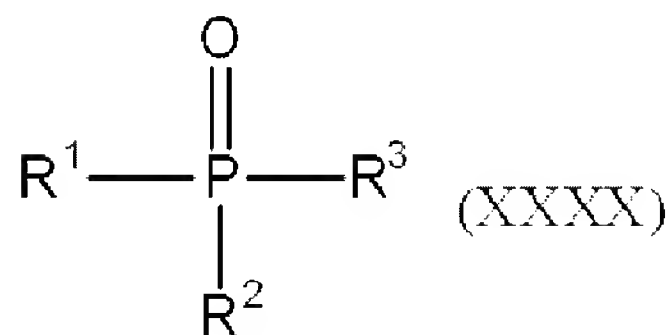
of less than 0.2 wt % may lead to deterioration in flame retarding effect. An amount of more than 3.0 wt % may lead to deterioration in moldability and moisture resistance and exudation of the phosphoric ester during molding, and consequently to deterioration in appearance.

[0059]

When used as a flame retardant, the phosphine oxide is preferably a compound represented by the following General Formula (XXXX).

10 [0060]

[Formula 21]



(wherein,  $\text{R}^1$ ,  $\text{R}^2$  and  $\text{R}^3$  each represent a substituted or unsubstituted alkyl, aryl, or aralkyl group having 1 to 10 carbon atoms or a hydrogen atom. and these groups may be the same as or different from each other; however, all of the groups are not hydrogen atoms at the same time).

Among the phosphorus compounds represented by General Formula (XXXX), those having substituted or unsubstituted aryl groups as  $\text{R}^1$  to  $\text{R}^3$  are preferable from the viewpoint of hydrolysis resistance, and those having phenyl groups are particularly preferable.

[0061]

It is necessary that the amount of the phosphine oxide blended is 0.01 to 0.2 wt % as phosphorus atom with respect to the sealant

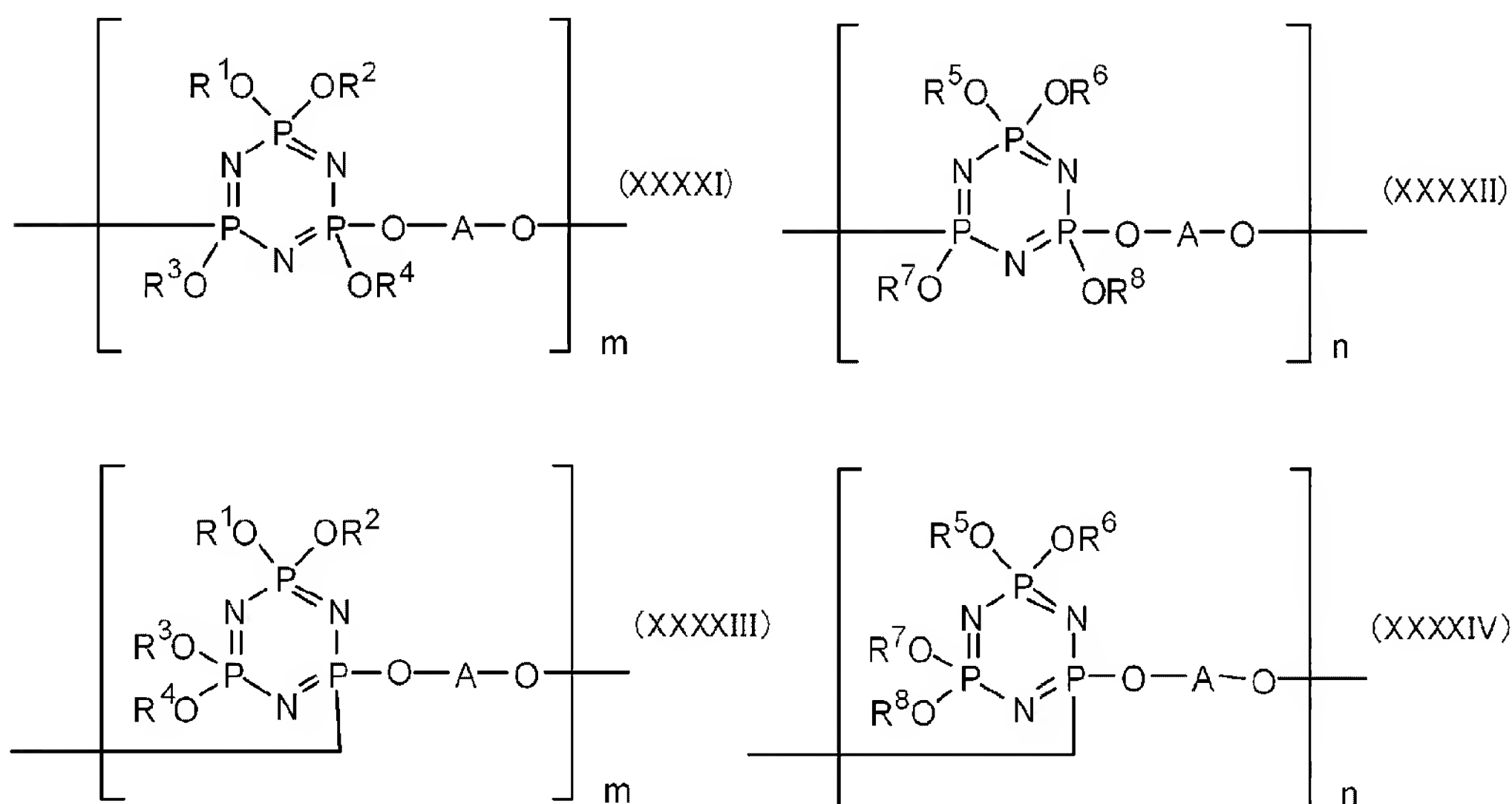
epoxy-resin molding material. It is preferably 0.02 to 0.1 wt % and more preferably 0.03 to 0.08 wt %. An amount of less than 0.01 wt % leads to deterioration in flame resistance, while an amount of more than 0.2 wt % to deterioration in moldability and moisture resistance.

[0062]

Examples of the cyclophosphazenes include cyclic phosphazene compounds having the groups represented by the following Formula (XXXXI) and/or the following Formula (XXXXII) as recurring units in the main chain skeleton, the isomers of the compounds having the groups represented by the following Formula (XXXXIII) and/or the following Formula (XXXXIV) as recurring units different in the substitution site of the phosphorus atoms in the phosphazene ring, and the like.

[0063]

[Formula 22]



In Formulae (XXXXI) and (XXXXIII), m is an integer of 1 to

10;  $R^1$  to  $R^4$  each represent a group selected from alkyl and aryl groups having 1 to 12 carbon atoms that may be substituted and a hydroxyl group, and may be the same as or different from each other. A represents an alkylene group having 1 to 4 carbon atoms or arylene group. In Formulae (XXXXII) and (XXXXIV), n is an integer of 1 to 10;  $R^5$  to  $R^8$  each represent a group selected from alkyl and aryl groups having 1 to 12 carbon atoms that may be substituted, and may be the same as or different from each other; and A represents an alkylene group having 1 to 4 carbon atoms or arylene group. Also in the Formulae, all m groups of  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  may be the same as or different from each other, and all n groups of  $R^5$ ,  $R^6$ ,  $R^7$ , and  $R^8$  may be the same as or different from each other. In Formulae (XXXXI) to (XXXXIV), the alkyl or aryl group having 1 to 12 carbon atoms that may be substituted represented by  $R^1$  to  $R^8$  is not particularly limited, and examples thereof include alkyl groups such as methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, and tert-butyl; aryl groups such as phenyl, 1-naphthyl, and 2-naphthyl group; alkyl group-substituted aryl groups such as o-toluyyl, m-toluyyl, p-toluyyl, 2,3-xylyl, 2,4-xylyl, o-cumenyl, m-cumenyl, p-cumenyl, and mesityl; aryl group-substituted alkyl groups such as benzyl and phenethyl; and the like, and examples of the substituent groups to the group include alkyl groups, alkoxyl groups, aryl groups, a hydroxyl group, an amino group, an epoxy group, a vinyl group, hydroxyalkyl groups, alkylamino groups and the like.

Among them, aryl groups are preferable, and a phenyl or hydroxyphenyl group is more preferable, from the viewpoints of

the heat resistance and moisture resistance of the epoxy resin molding material.

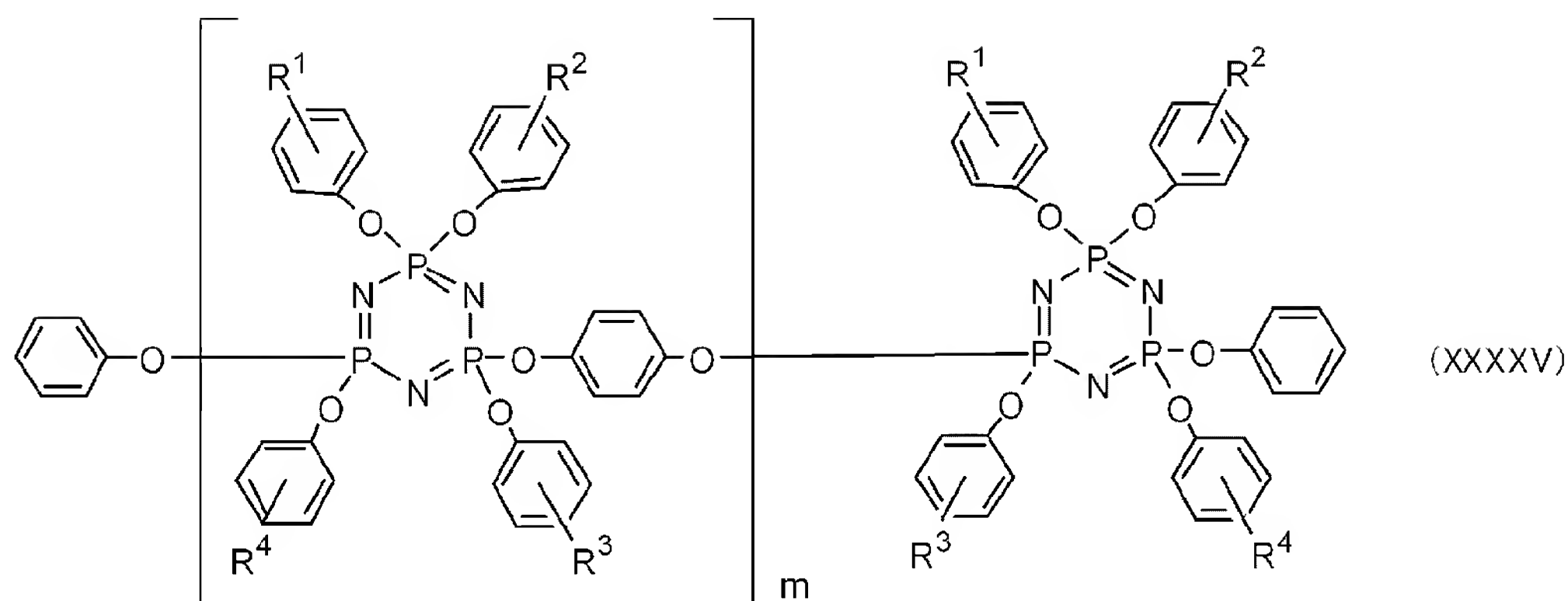
Also in Formulae (XXXXI) to (XXXXIV), the alkylene or arylene group having 1 to 4 carbon atoms represented by A is not particularly  
 5 limited, and example thereof include methylene, ethylene, propylene, isopropylene, butylene, isobutylene, phenylene, tolylene, xylylene, and naphthylene groups, and the like; an arylene groups are preferable from the viewpoints of the heat resistance and moisture resistance of the epoxy resin molding  
 10 material, and among them, a phenylene group is more preferable.

The cyclic phosphazene compound may be a polymer of one of the units represented by Formulae (XXXXI) to (XXXXIV) or a copolymer of the units represented by Formulae (XXXXI) and (XXXXII) or by Formulae (XXXXIII) and (XXXXIV); and, if it is a copolymer, the  
 15 copolymer may be a random, block or alternating copolymer. The copolymerization molar ratio  $m/n$  is not particularly limited, but preferably 1/0 to 1/4, more preferably 1/0 to 1/1.5, for improvement in the heat resistance and strength of the hardened epoxy-resin product. The polymerization degree  $m+n$  is 1 to 20, preferably  
 20 2 to 8, and more preferably 3 to 6.

Favorable examples of the cyclic phosphazene compounds include the polymers represented by the following Formula (XXXXV), the copolymers represented by the following Formula (XXXXVI), and the like.

25 [0064]

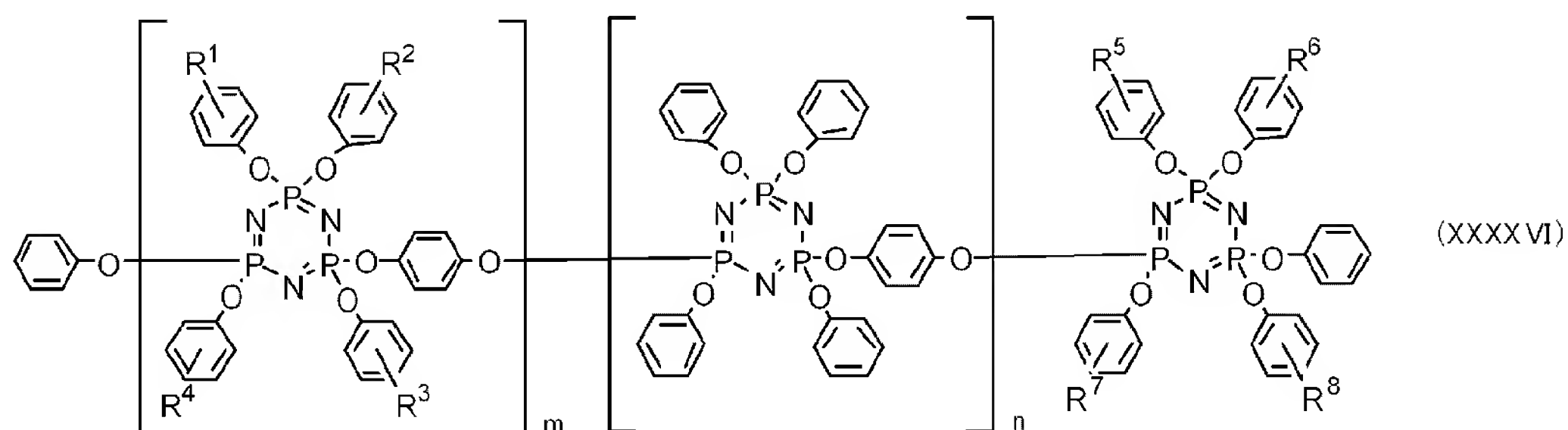
[Formula 23]



(in Formula (XXXXV),  $m$  is an integer of 0 to 9; and  $R^1$  to  $R^4$  each independently represent a hydrogen atom or a hydroxyl group).

5 [0065]

[Formula 24]

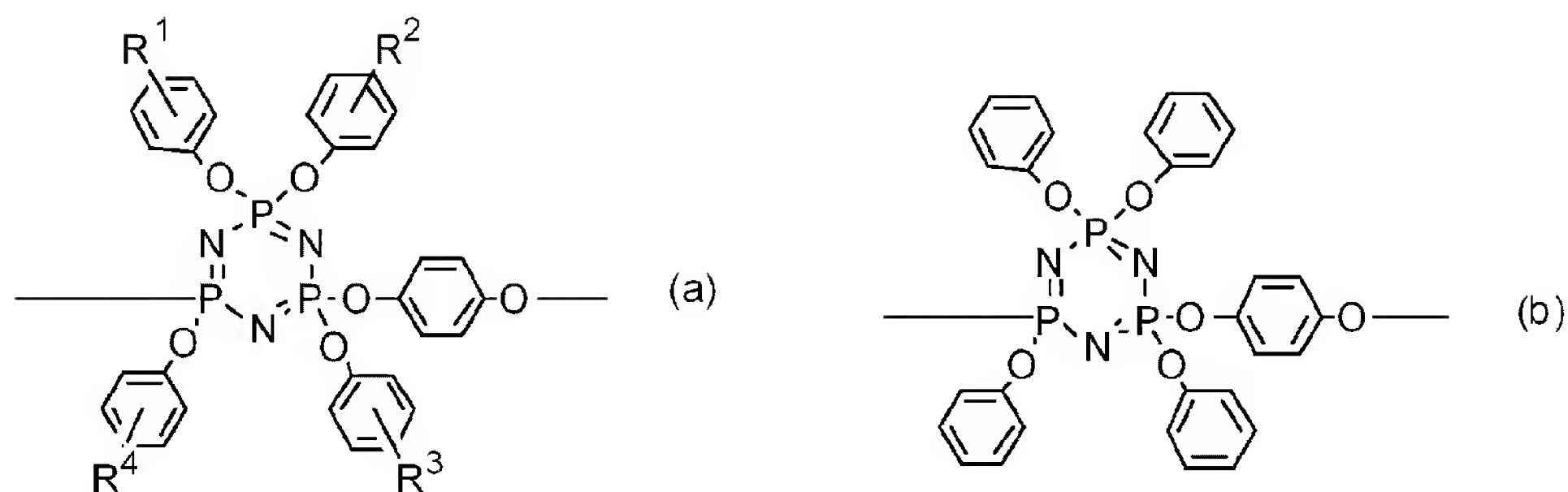


In Formula (XXXXVI) above, each of  $m$  and  $n$  is an integer of 0 to 9;  $R^1$  to  $R^4$  each independently represent a hydrogen atom or a hydroxyl group; and  $R^5$  to  $R^8$  each independently represent a hydrogen atom or a hydroxyl group. The cyclic phosphazene compound represented by Formula (XXXXVI) above may be a copolymer containing  $m$  recurring units (a) and  $n$  recurring units (b) shown below alternately, blockwise, or random, but preferably a random copolymer.

[0066]

[Formula 25]





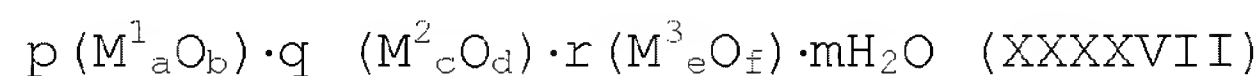
Among them, the cyclic phosphazene compound is preferably a compound containing a polymer in which  $m$  in Formula (XXXXV) is 3 to 6 as the principal component, or that containing a copolymer in which all of  $R^5$  to  $R^8$  in Formula (XXXXVI) are hydrogen atoms, or only one of them is a hydroxyl group,  $m/n$  is  $1/2$  to  $1/3$ , and  $m+n$  is 3 to 6, as the principal component. Commercially available phosphazene compounds include SPE-100 (trade name, manufactured by Otsuka Chemical Co., Ltd.).

[0067]

When used as a flame retardant, the composite metal hydroxide is preferably a compound represented by the following Compositional Formula (XXXXVII).

[0068]

[Formula 26]

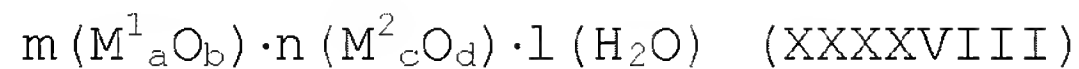


(wherein,  $M^1$ ,  $M^2$  and  $M^3$  represent metal ions that are different from each other; each of  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $e$ ,  $f$ ,  $p$ ,  $q$  and  $m$  is a positive number; and  $r$  is 0 or a positive number).

Among them, the compounds represented by Formula (XXXXVII) in which  $r$  is 0, i.e., compounds represented by the following Formula (XXXXVIII), are more preferable.

[0069]

[Formula 27]



(wherein,  $M^1$  and  $M^2$  represent metal elements different from  
5 each other; and each of  $a, b, c, d, m, n$  and  $l$  is a positive number).

$M^1, M^2$  and  $M^3$  in Compositional Formulae (XXXXVII) and  
(XXXXVIII) above are not particularly limited if they are different  
from each other, but, preferably from the viewpoint of  
flame-retardant viewpoint,  $M^1$  is selected from metal elements in  
10 the third period, alkali-earth metal elements in group IIA, and  
metal elements in groups IVB, IIB, VIII, IB, IIIA and IVA, and  
 $M^2$  is selected from transition metal elements in groups IIIB to  
IIB, to make  $M^1$  and  $M^2$  different from each other; and more preferably,  
 $M^1$  is selected from magnesium, calcium, aluminum, tin, titanium,  
15 iron, cobalt, nickel, copper and zinc, and  $M^2$  is selected from  
iron, cobalt, nickel, copper and zinc. Preferably from the  
viewpoint of flowability,  $M^1$  is magnesium and  $M^2$  is zinc or nickel;  
and more preferably,  $M^1$  is magnesium and  $M^2$  is zinc.

The molar ratio of  $p, q$ , and  $r$  in Compositional Formula  
20 (XXXXVII) above is not particularly limited, as far as the  
advantageous effects of the present invention is obtained; but  
preferably,  $r$  is 0, and the molar ratio of  $p$  and  $q$ ,  $p/q$ , is 99/1  
to 50/50. That is, the molar ratio of  $m$  and  $n$ ,  $m/n$ , in Compositional  
Formula (XXXXVIII) above is preferably 99/1 to 50/50.

25 Examples of commercially available products include a  
composite metal hydroxide (magnesium hydroxide and zinc hydroxide  
solid solution, trade name: ECOMAG Z-10, manufactured by Tateho

Chemical Industries Co., Ltd.) in which  $M^1$  in the Compositional Formula (XXXXVIII) is magnesium,  $M^2$  is zinc, m is 7, n is 3, l is 10, and a, b, c and d are 1. The metal elements described above also include semimetal elements, and thus include all elements  
5 excluding nonmetal elements.

Metal elements are determined, based on the long periodic table grouping typical elements in subgroup A and transition elements in subgroup B ("Dictionary of Chemistry 4", reduce-size Ed., 30th, published by Kyoritsu Shuppan Co., Ltd., Feb. 15, 1987).  
10 [0070]

The shape of the composite metal hydroxide is not particularly limited, but is preferably polyhedron having a suitable thickness rather than in the flat plate shape, from the viewpoints of flowability and performance of filling. Composite  
15 metal hydroxides are obtained as polyhedral crystal more easily than metal hydroxides.

The blending amount of the composite metal hydroxide is not particularly limited, but preferably 0.5 to 20 wt %, more preferably, 0.7 to 15 wt %, and still more preferably 1.4 to 12 wt %, with  
20 respect to the sealant epoxy-resin molding material. An amount of less than 0.5 wt % may lead to deterioration in flame resistance, while an amount of more than 20 wt % to deterioration in flowability and reflow resistance.

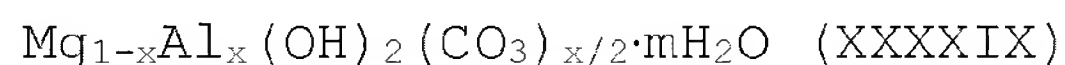
[0071]

25 Also an anion exchanger may be added to the sealant epoxy-resin molding material according to the present invention for improvement in the moisture resistance and high-temperature

storage stability of semiconductor elements such as IC. The anion exchanger is not particularly limited, and any one of known exchangers may be used. Examples thereof include hydrotalcites, hydrated metal oxides of an element selected from magnesium, aluminum, titanium, zirconium, and bismuth, and the like, and these may be used alone or in combination of two or more. Among them, the hydrotalcite represented by the following Compositional Formula (XXXXIX) is preferable.

[0072]

10 [Formula 28]



(wherein,  $0 < x \leq 0.5$ , and  $m$  is a positive number).

[0073]

In addition, other additives, including a releasing agent such as higher fatty acid, higher fatty acid metal salt, ester-based wax, polyolefin wax, polyethylene, or oxidized polyethylene; a colorant such as carbon black; and a stress-relaxing agent such as silicone oil or silicone rubber powder, may be added as needed to the sealant epoxy-resin molding material according to the present invention.

[0074]

The sealant epoxy-resin molding material according to the present invention is preferably used after previously melt-mixed with an epoxy resin (A) and a hardening agent (B) from the viewpoint of flame resistance. The melt-mixing method is not particularly limited, but they are preferably melted and mixed until becoming uniform, while heated at a temperature or more at which all or

at least one of them melt. It is preferable to determine the optimal condition then for prevention of gelation, by studying the reactivity, for example, by GPC (gel-permeation chromatography) or FT-IR. When a compound represented by General Formula (I) above is used as the epoxy resin (A) and a compound represented by General Formula (II) above as the hardening agent (B), the resins are preferably melt-mixed at 80 to 120°C, more preferably 90 to 120°C, for 10 to 60 minutes, more preferably 20 to 40 minute.

[0075]

The sealant epoxy-resin molding material according to the present invention may be prepared by any method, if various raw materials are dispersed and mixed uniformly thereby, and, in a general method, raw materials in blending amounts are mixed sufficiently, for example in a mixer, mixed or melt-kneaded, for example in a mixing roll, extruder, mortar and pestle machine, or planetary mixer, cooled, furthermore, degassed and pulverized as needed. The molding material may be tabletized into the size and weight suitable for the molding condition as needed.

[0076]

A low-pressure transfer molding method is most commonly used as the method of sealing electronic component devices such as semiconductor device by using the sealant epoxy-resin molding material according to the present invention as a sealant, but other method such as injection molding or compression molding may be used instead. Yet another method such as discharging, molding, or printing may be used.

[0077]

The electronic component devices according to the present invention having an element sealed with the sealant epoxy-resin composition according to the present invention include electronic component devices having an element, for example as an active  
5 element such as semiconductor chip, transistor, diode or thyristor or a passive element such as capacitor, resistor or coil, formed on a supporting material or mounting substrate such as lead frame, wired tape support, wiring board, glass, or silicon wafer, of which desirable regions are sealed with the sealant epoxy-resin  
10 composition according to the present invention, and the like.  
[0078]

The substrate for mounting is not particularly limited, and examples thereof include organic substrates, organic films, ceramic substrates, interposer substrates such as of glass plate,  
15 glass plates for liquid crystal, MCM (Multi Chip Module) substrates, hybrid IC substrates, and the like.

Examples of the electronic component devices include semiconductor devices, and typical examples thereof include resin-sealed IC's prepared by mounting an element such as  
20 semiconductor chip on a lead frame (island, tab), connecting the terminal of the element such as bonding pad and lead areas by wire bonding or bumping, and then, sealing the element with the sealant epoxy-resin molding material according to the present invention for example by transfer molding, such as DIP (Dual Inline Package),  
25 PLCC (Plastic Leaded Chip Carrier), QFP (Quad Flat Package), SOP (Small Outline Package), SOJ (Small Outline J-lead Package), TSOP (Thin Small Outline Package), and TQFP (Thin Quad Flat Package);

TCP's (Tape Carrier Packages) prepared by sealing a semiconductor chip lead-bonded to a tape support with the sealant epoxy-resin molding material according to the present invention; semiconductor devices mounted on bare chip, such as COB's (Chip On Board) and  
5 COG (Chip On Glass), prepared by sealing a semiconductor chip connected to a wiring formed on a wiring board or glass plate with the sealant epoxy-resin molding material according to the present invention, for example by wire bonding, flip-chip bonding, or soldering; hybrid IC's prepared by sealing an active element such  
10 as semiconductor chip, transistor, diode, or thyristor and/or a passive element such as capacitor, resistor, or coil connected to a wiring formed on a wiring board or glass with the sealant epoxy-resin molding material according to the present invention, for example by wire bonding, flip chip bonding, or solder; BGA's  
15 (Ball Grid Arrays), CSP's (Chip Size Packages), and MCP's (Multi Chip Packages) prepared by mounting a semiconductor chip on an interposer substrate having a terminal for connection to a MCM (Multi Chip Module) mother board, connecting the semiconductor chip to a wiring formed on the interposer substrate by bumping  
20 or wire bonding, and then, sealing the semiconductor chip-sided surface of the substrate with the sealant epoxy-resin molding material according to the present invention; and the like. The semiconductor device may be a stacked package in which two or more elements are mounted as stacked (laminated) on a mounting substrate,  
25 or a simultaneously molding package in which two or more elements are sealed simultaneously with a sealant epoxy-resin molding material.

[EXAMPLES]

[0079]

Hereinafter, the present invention will be described with  
5 reference to Examples, but it should be understood that the scope  
of the present invention is not limited to these Examples.

(Examples 1 to 24 and Comparative Examples 1 to 14)

Epoxy resins used below were an epoxy resin from the monomer  
represented by Formula (IV) having an epoxy equivalence of 180  
10 and a melting point of 105°C (trade name: EPIKOTE YL-7172,  
manufactured by Japan Epoxy Resin Co., Ltd. epoxy resin 1); a  
biphenylene-based epoxy resin having an epoxy equivalence of 273  
and a softening point of 58°C (trade name: NC-3000, manufactured  
by Nippon Kayaku Co., Ltd., epoxy resin 2); a biphenyl-based epoxy  
15 resin having an epoxy equivalence of 196 and a melting point of  
106°C (trade name: EPIKOTE YX-4000H, manufactured by Japan Epoxy  
Resin Co., Ltd., epoxy resin 3); a sulfur atom-containing epoxy  
resin having an epoxy equivalence of 245 and a melting point of  
110°C (trade name: YSLV-120TE, manufactured by Tohto Kasei Co.,  
20 Ltd., epoxy resin 4); and an o-cresol novolak epoxy resin having  
an epoxy equivalence of 195 and a softening point of 65°C (trade  
name: ESCN-190, manufactured by Sumitomo Chemical Co., Ltd., epoxy  
resin 5). The hardening agents used were a phenol-aralkyl resin  
having a softening point of 70°C and a hydroxyl group equivalence  
25 of 175 (trade name: Milex XLC-3L, manufactured by Mitsui Chemicals,  
Inc., hardening agent 1); a biphenylene-based phenol resin having  
a softening point of 80°C and a hydroxyl group equivalence of 199



(trade name: MEH-7851, manufactured by Meiwa Plastic Industries, Ltd., hardening agent 2); a  $\beta$ -naphthol-aralkyl resin having a hydroxyl group equivalence 182 and a softening point of 67°C (trade name: SN-170, manufactured by Nippon Steel Chemical Co., Ltd.,  
5 hardening agent 3); an acenaphthylene-containing  $\beta$ -naphthol-aralkyl resin having a hydroxyl group equivalence of 199 and a softening point 78°C (trade name: SN-170AR-10, manufactured by Nippon Steel Chemical Co., Ltd., hardening agent 4); and a phenolic novolak resin having a softening point of 80°C  
10 and a hydroxyl group equivalence of 106 (trade name: H-1, manufactured by Meiwa Plastic Industries, Ltd., hardening agent 5). The hardening accelerators used were triphenylphosphine (accelerator 1), an adduct of triphenylphosphine of 1,4-benzoquinone (accelerator 2), and  
15 1,8-diazabicyclo[5.4.0]undecene-7 (accelerator 3). The coupling agents used were  $\gamma$ -glycidoxypropyltrimethoxysilane (epoxysilane) and a secondary amino group-containing silane-coupling agent ( $\gamma$ -anilinopropyltrimethoxysilane (anilinosilane)); the flame retardants used were a condensed  
20 aromatic phosphoric ester (trade name: PX-200, manufactured by Daihachi Chemical Industry Co., Ltd.), triphenylphosphine oxide, cyclophosphazene (trade name: SPE-100, manufactured by Otsuka Chemical Co., Ltd.), a composite metal hydroxide (magnesium hydroxide and zinc hydroxide solid solution, trade name: ECOMAG  
25 Z-10, manufactured by Tateho Chemical Industries Co., Ltd.), zinc molybdenate (trade name: KEMGARD911B, manufactured by Sherwin-Williams), zinc borate (trade name: FRZ-500C,

manufactured by Mizusawa Industrial Chemicals, Ltd.), antimony trioxide, and a bisphenol-A-based brominated epoxy resin having an epoxy equivalence of 397, a softening point of 69°C, and a bromine content of 49 wt % (trade name: YDB-400, manufactured by Tohto Kasei Co., Ltd.); and the inorganic filler used was spherical fused silica having an average diameter of 14.5  $\mu\text{m}$  and a specific surface area of 2.8  $\text{m}^2/\text{g}$ . The other additives used were carnauba wax (manufactured by Clariant (Japan) K.K.), and carbon black (trade name: MA-100, manufactured by Mitsubishi Chemical Corp.). These raw materials were blended in the compositions by mass respectively shown in Tables 1 to 5, roll-kneaded under the condition of a kneading temperature of 80°C and a kneading period of 10 minutes, to give the compositions of Examples 1 to 24 and Comparative Examples 1 to 14. The melted resin 1 in Example 18 is prepared as follows:

<Preparation of melted resin 1>

150 g of YL-7172 above and 146 g of XLC-3L above were placed in a 500-mL separable flask equipped with a stirring rod, a thermometer, a nitrogen-supplying tube and a condenser tube, and the mixture was blended under heat in an oil bath at 130°C. The mixture was stirred for 30 minutes after melting, and the melted resin was cooled in a vat, to give a melted resin 1.

[0080]

[Table 1]

Table 1 composition for blend 1

Blended components	Examples							
	1	2	3	4	5	6	7	8
epoxy resin 1	100	100	100	100	100	100	100	100
epoxy resin 2								
epoxy resin 3								
epoxy resin 4								
epoxy resin 5								
brominated epoxy resin								
hardening agent 1	97	97	97	97	97	97	97	97
hardening agent 2								
hardening agent 3								
hardening agent 4								
hardening agent 5								
melted resin 1								
accelerator 1	2.0	2.0	2.0	2.0	2.0	2.0		
accelerator 2							2.5	
accelerator 3								2.0
phosphoric ester triphenyl phosphine oxide								
cyclophosphazene								
composite metal hydroxide								
zinc molybdenate								
zinc borate								
antimony trioxide								
epoxysilane	1.0	1.0	1.0	1.0	1.0		1.0	1.0
anilinosilane						1.0		
carnauba wax	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
carbon black	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
fused silica	302	470	1155	1754	3892	1155	1158	1155
filler content (wt%)	60	70	85	90	95	85	85	85

[0081]

[Table 2]

Table 2 composition for blend 2

Blended components	Examples							
	9	10	11	12	13	14	15	16
epoxy resin 1	100	100	100	100	50	20	50	50
epoxy resin 2					50	70		
epoxy resin 3							50	
epoxy resin 4								50
epoxy resin 5								
brominated epoxy resin								
hardening agent 1					81	64	93	84
hardening agent 2	111							
hardening agent 3		101						
hardening agent 4			111					
hardening agent 5				59				
melted resin 1								
accelerator 1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
accelerator 2								
accelerator 3								
phosphoric ester								
triphenyl								
phosphine oxide								
cyclophosphazene								
composite								
metal hydroxide								
zinc molybdenate								
zinc borate								
antimony trioxide								
epoxysilane	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
anilinosilane								
carnauba wax	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
carbon black	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
fused silica	1230	1177	1230	939	1061	913	1132	1082
filler content (wt%)	85	85	85	85	85	85	85	85

[0082]

[Table 3]

Table 3 composition for blend 3

Blended components	Examples							
	17	18	19	20	21	22	23	24
epoxy resin 1	50		100	100	100	100	100	100
epoxy resin 2								
epoxy resin 3								
epoxy resin 4								
epoxy resin 5	50							
brominated epoxy resin								
hardening agent 1	93		97	97	97	97	97	97
hardening agent 2								
hardening agent 3								
hardening agent 4								
hardening agent 5								
melted resin 1		197						
accelerator 1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
accelerator 2								
accelerator 3								
phosphoric ester triphenyl phosphine oxide			10	10				
cyclophosphazene composite					10			
metal hydroxide						50		
zinc molybdenate							5	
zinc borate								10
antimony trioxide								
epoxysilane	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
anilinosilane								
carnauba wax	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
carbon black	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
fused silica	1134	1154	317	317	317	257	302	302
filler content (wt%)	85	85	60	60	60	60	60	60

[0083]

[Table 4]

Table 4 composition for blend 4

Blended components	Comparative Examples							
	1	2	3	4	5	6	7	8
epoxy resin 1	100	100	100	100	100	100	100	100
epoxy resin 2								
epoxy resin 3								
epoxy resin 4								
epoxy resin 5								
brominated epoxy resin								
hardening agent 1	73	73	73	73	73	64	89	71
hardening agent 2								
hardening agent 3								
hardening agent 4								
hardening agent 5								
melted resin 1								
accelerator 1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
accelerator 2								
accelerator 3								
phosphoric ester								
triphenylphosphine oxide								
cyclophosphazene composite								
metal hydroxide								
zinc molybdenate								
zinc borate								
antimony trioxide								
epoxysilane	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
anilinosilane								
carnauba wax	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
carbon black	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
fused silica	267	415	1018	1545	3430	968	1110	1009
filler content (wt%)	60	70	85	90	95	85	85	85

[0084]

[Table 5]

Table 5 composition for blend 5

Blended components	Comparative Examples					
	9	10	11	12	13	14
epoxy resin 1	100	100	100	100	100	85
epoxy resin 2						
epoxy resin 3						
epoxy resin 4						
epoxy resin 5						
Brominated epoxy resin						15
hardening agent 1	90	89	89	89	89	83
hardening agent 2						
hardening agent 3						
hardening agent 4						
hardening agent 5						
melted resin 1						
accelerator 1	2.0	2.0	2.0	2.0	2.0	2.0
accelerator 2						
accelerator 3						
phosphoric ester triphenyl phosphine oxide		30	30	30	100	10
cyclophosphazene composite						
metal hydroxide						
antimony trioxide						
epoxysilane	1.0	1.0	1.0	1.0	1.0	1.0
anilinosilane						
carnauba wax	2.0	2.0	2.0	2.0	2.0	2.0
carbon black	2.5	2.5	2.5	2.5	2.5	2.5
fused silica	1113	1279	1279	1279	992	1070
filler content (wt%)	85	85	85	85	85	85

Properties of the sealant epoxy-resin compositions prepared in Examples 1 to 24 and Comparative Examples 1 to 14 were determined in the following tests. Results are summarized in Tables 6 to 10.

(1) Spiral flow

The flow distance (cm) of each sealant epoxy-resin composition was determined in a transfer-molding machine by molding it, by using a mold compatible with EMMI-1-66 for spiral flow measurement under the condition of a mold temperature of 180°C, a molding pressure of 6.9 MPa, and a hardening period of 90 seconds.

[0085]

(2) Hardness when hot

Each sealant epoxy-resin composition was molded into a circular disk having a diameter of 50 mm and a thickness of 3 mm under the molding condition of (1), and immediately the hardness thereof was determined by using a Shore D hardness meter.

[0086]

(3) Flame resistance

Each sealant epoxy-resin composition was molded under the molding condition of (1) by using a mold die for a sample having a thickness of 1/16 inch and hardened at 180°C for 5 hours as a post cure, and the flame resistance thereof is determined according to the test method of UL-94.

[0087]

(4) Reflow resistance

An 80-pin flat package (QFP) having an external size of 20 mm × 14 mm × 2 mm carrying a silicon chip of 8 mm × 10 mm × 0.4



mm in size was molded and post cured by using each sealant epoxy-resin composition under the condition of (3), moistened under the condition of 85°C and 85% RH, and subjected to reflow treatment at a particular time interval at 240°C for 10 seconds; presence  
 5 of cracks then was determined; and the reflow resistance was evaluated, based on the number of packages cracks generated on five test packages.

[0088]

(5) Moisture resistance

10 An 80-pin flat package (QFP) having an external dimension of 20 mm × 14 mm × 2.7 mm carrying a test silicon chip of 6 mm × 6 mm × 0.4 mm in size with aluminum wiring having a line width 10 μm and a thickness 1 μm on an oxide layer having thickness of 5 μm was molded and post cured by using each sealant epoxy-resin  
 15 composition under the condition of (3) and moistened after pretreatment; disconnection defects by aluminum wiring corrosion was analyzed at a particular time interval; and the moisture resistance thereof is evaluated, based on the number of defective packages on ten test packages.

20 In the pretreatment, the flat package was moistened under the condition of 85°C and 85% RH for 72 hours and subjected to a vapor-phase reflow treatment at 215°C for 90 seconds. Then, it is moistened under the condition of 0.2 MPa and 121°C.

[0089]

25 (6) High-temperature storage stability

A test silicon chip of 5 mm × 9 mm × 0.4 mm in size carrying aluminum wiring having a line width 10 μm and a thickness of 1

$\mu\text{m}$  formed on the oxide layer having a thickness of  $5\ \mu\text{m}$  was mounted with silver paste on a 42-alloy lead frame partially silver-plated; a 16-pin DIP (Dual Inline Package), in which the bonding pad of the chip and the inner lead were connected to each other with Au wire at  $200^{\circ}\text{C}$  with a thermosonic bonder, was prepared by molding with each sealant epoxy-resin composition and post curing under the conditions of (3), and stored in a tank at a high temperature of  $200^{\circ}\text{C}$ ; the DIP was withdrawn from the tank at a particular time interval and subjected to a continuity test; and the high-temperature storage stability was evaluated by the number of continuity defective packages on ten test packages.

[0090]

[Table 6]

Table 6 properties of sealant 1

[illegible]

Table 7 properties of sealant 2

[illegible]

[0092]

[Table 8]

Table 8 properties of sealant 3

Properties	Examples							
	17	18	19	20	21	22	23	24
Flame resistance								
Total flame remain time (s)	50	5	12	15	20	14	33	30
Judgment	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0
Spiral flow (cm)	95	125	180	176	181	103	122	111
Hardness when hot (Shore D)	80	75	58	60	55	74	73	70
Reflow								
Resistance 48h	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5
72h	3/5	0/5	3/5	4/5	3/5	0/5	0/5	0/5
96h	5/5	0/5	5/5	5/5	5/5	2/5	0/5	5/5
168h	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Moisture resistance								
100h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
500h	0/10	0/10	0/10	0/10	2/10	0/10	0/10	0/10
1000h	0/10	0/10	2/10	0/10	5/10	0/10	0/10	0/10
1500h	0/10	0/10	7/10	5/10	8/10	0/10	0/10	2/10
High-temperature storage stability								
500h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
1000h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
1500h	0/10	0/10	0/10	0/10	1/10	0/10	0/10	0/10
2000h	0/10	0/10	3/10	2/10	3/10	0/10	0/10	0/10

Table 9 properties of sealant 4

[illegible]

[0094]

[Table 10]

Table 10 properties of sealant 5

Properties	Comparative Examples					
	9	10	11	12	13	14
Flame resistance						
Total flame remain time (s)	clamp	37	30	40	22	5
Judgment	non-standard	V-0	V-0	V-0	V-0	V-0
Spiral flow (cm)	82	182	173	181	73	128
Hardness when hot (Shore D)	85	59	61	54	70	73
Reflow resistance						
48h	5/5	0/5	0/5	0/5	0/5	0/5
72h	5/5	4/5	5/5	5/5	1/5	0/5
96h	5/5	5/5	5/5	5/5	2/5	0/5
168h	5/5	5/5	5/5	5/5	5/5	2/5
Moisture resistance						
100h	0/10	0/10	0/10	0/10	0/10	0/10
500h	0/10	0/10	0/10	4/10	0/10	0/10
1000h	0/10	5/10	2/10	8/10	0/10	0/10
1500h	0/10	10/10	7/10	10/10	0/10	0/10
High-temperature storage stability						
500h	0/10	0/10	0/10	0/10	0/10	3/10
1000h	0/10	0/10	0/10	0/10	0/10	10/10
1500h	0/10	0/10	0/10	3/10	0/10	10/10
2000h	0/10	5/10	5/10	7/10	0/10	10/10

[0095]

The samples obtained in Comparative Examples 1 to 9, which contained no epoxy resin represented by the General Formula (I) according to the present invention and no flame retardant, were all inferior in flame resistance, and could not satisfy the requirements of UL-94 V-0. Among the samples obtained in Comparative Examples 10 to 14, which contained no epoxy resin represented by the General Formula (I) but contains various flame retardants, the samples in Comparative Examples 10 to 12 were inferior in moisture resistance. Alternatively, the sample of Comparative Example 13 was inferior in flowability. Yet alternatively, the sample obtained in Comparative Example 14 satisfied the requirements of V-0, but was inferior in high-temperature storage stability.

In contrast, all of the samples obtained in Examples 1 to 24, which contained the epoxy resin represented by the General Formula (I), satisfied the requirements of UL-94 V-0, and was superior in flame resistance and also in moldability. In addition, the samples obtained in Examples 2 to 11, 13 to 16, 18 and 22 to 24 were superior in reflow resistance, and the samples of Examples 1 to 20 and 22 to 24 were superior in reliability, specifically in moisture resistance and high temperature storage stability.